SAE Journal

OCTOBER 1959

IN THIS ISSUE . . .

Published by The Society of Automotive Engineers

1959 Technical Report No. 4

Field Service...

safeguard to product reputation

Severe environmental conditions or abnormal operation of internal combustion engines will ultimately cause trouble...ranging from premature impairment of efficiency to complete breakdown.

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Publication Office
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Society Headquarters
Editorial and Advertising Office
485 Lexington Ave., New York 17, N. Y.
Tel: OXford 7-3340; Teletype: NY1 228

Detroit Branch manager, G. J. Gaudaen
635 New Center Bldg., Detroit 2, Mich.
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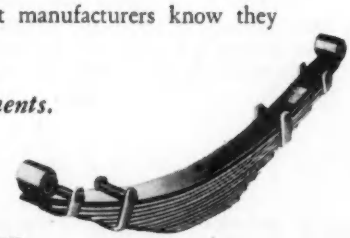

Briefs of SAE PAPERS

Presented here are brief digests of recently presented SAE papers. These papers are available in full in multilith form for one year after presentation. To order, circle the numbers in the "Readers Information Service" blank on page 6 corresponding to the numbers appearing after the titles of the digests of interest to you.

AIRCRAFT

Jet Powerplant Requirements for VTOL, C. T. HEWSON. Paper No. 64R. How type of aircraft and flight plan determine to large extent type of power plant chosen; with particular reference to wing borne power plant, author discusses characteristics of light weight, low fuel consumption, small size, low drag, quietness, fast thrust response, small ground effects, and high emergency power.

Effect of Vertical Flight on Powerplant Design, J. A. O'MALLEY, Jr., A. M. JACKES. Paper No. 64T. State of development and factors in design of propulsion systems; possibilities for improved performance with regard to thrust vector, augmentation of thrust, control systems, and installation interference; emphasis placed on exploitation of increased turbine temperatures and simple and light variable geometry in power plant to produce high takeoff as well as cruise performance.

Comparison of Vanguard and Sputnik Launching Vehicles, S. B. KRAMER. Paper No. S154. Process of calculation with regard to probable size and first stage thrust for Sputnik launching vehicle is attempted, assuming vehicle to be "standard" 3-stage tandem rocket; assumptions regarding fuel and oxidizer used; trajectory is approximated by trolley car equations; table shows comparison of Vanguard and Sputnik; payload optimization for Sputnik III.

Present Status and Future Potential of VTOL Aircraft, G. D. RAY. Paper No. S155. Examination of some characteristics in order to understand reason that underly landing and takeoff performance of conventional airplane and helicopter; current VTOL aircrafts; need for family of bypass engines having higher bypass ratios when used with lower speed aircraft, stressed; development should be directed toward higher turbine inlet temperature and geometry variations in fan and turbine; aproach recommended to horizontal attitude aircraft in which thrust direction only is varied.

Propulsion Spectrum for VTOL Aircraft, D. A. RICHARDSON. Paper No. 64S. Discussion particularly concerned with transport types of craft, covering various propulsion system characteristics from low speed end represented by helicopter through intermediate speed VTOL's to high speed VTOL's: problems of range, hovering characteristics, etc, as related to fuel economy; problem of engine speed range and other factors determining propulsion spectrum from propeller to jet systems.

FUELS & LUBRICANTS

Some Factors Contributing Towards Successful Lubrication of Small European Two-Stroke Petrol Engines, A. TOWLE. Paper No. 66T. Reasons for adoption of 2-stroke cycle for small motor cycles, motor scooters, and miniature cars; test program to investigate problem of 2-stroke lubrication; major problems involved; selection of suitable lubricating oil; it is concluded that suitably treated medium VI SAE 30 oils containing 10% to 20% of bright stock have best all around properties.

High Compression — Is it Worth It? C. L. GOODACRE, B. H. WATKINS. Paper No. 66W. Progress report on research by Associated Ethyl Co., Great Britain, to develop fuels of increasing resistance to chemical instability under high temperature pressure conditions; dynamometer and road tests on standard engine and car run on marketed gasoline with relative adjustment to antiknock quality indicate that power and specific fuel consumption are improved as compression ratio is raised; refinements to physical characteristics at given compression ratio resulted in increases in thermal efficiency and power.

What is Needed in Two Cycle Engine Oil? J. W. SAVIN. Paper No. 65T. Results of laboratory engine program con-

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Briefs of SAE PAPERS

ducted to evaluate various elements contributing to performance of lubricant, show that additive oils tailored to outboard motor engine requirements provide level of lubricant performance far above that attained by best non-additive oils; table shows performance characteristics associated with representative base oils relating to naphthene or coastal type oils, paraffinic and compounded oils; results of field tests.

Lubrication Studies of Two-Cycle Gasoline Engines, H. V. LOWTHER, G. H. SHEA, K. C. KRESGE. Paper No. 65U. Problems of engines such as are used for power lawn motors, generator sets, outboard engines, etc; various aspects of lubricant composition as related to engine operations and data which show those factors of base stock composition and of various additive classes which affect piston cleanliness, exhaust system deposits, wear, and spark plug operation.

Two-Cycle Engines Prefer Ashless Detergent Oils, L. O. BOWMAN, R. W. BURCHELL. Paper No. 65V. Laboratory engine program consisting of scooter engine tests and 10-hp outboard engine tests; it is concluded that oils containing ashless detergent provide excellent deposition control in variety of engines operating over wide range of speeds, loads, and temperatures.

Standardization of Lubricating Oil Engine Test Methods by Institute of Petroleum, N. KENDALL. Paper No. 66U. Engine tests of lubricants panel relating to status and aims of panel; outline of activities; comparison of Caterpillar L-1 and Petter AVL/AT.4 tests using common test oil; future program.

Multiengine Facilities — Tool for Fuel and Lubricant Research, L. S. ECHOLS, F. J. CORDERA. Paper No. 69T. 12-engine test facility and operating procedures employed at Shell Oil Co; instrumentation and methods used; typical results; use of statistical relationships to determine significance of results.

Evaluating Automatic Transmission Fluids. Paper No. SP-161 (Detroit Sec). Review of requirements of automatic transmission fluid, Type A, with particular emphasis on means and methods used in determining performance characteristics; tests for determining fluid characteristics; Type A oxidation tests; other motored transmission oxidation tests; durability cycling tests; squawk tests; tables, graphs and curves.

Contamination and Static Discharges — Problems in Turbine Fuel? G. T. COKER, Jr., H. R. HEIPLE. Paper No. S151. Approach taken by Shell Oil Co. to eliminate hazards from static discharge and contaminated fuel which are potentially serious problems in handling fuels for turbine powered aircraft; mechanism of static generation and techniques used to indicate presence of sparks; typical fuel distribution system and how contamination may enter fuel; objectives of program established at AEROSHELL Turbine Fuel Equipment Laboratory; recommendations.

GROUND VEHICLES

Small Cars, Pro and Con, L. E. CROOKS. Paper No. 71T. Paper based on Consumers Union's road test program, in which 40 to 50 small imported cars were tested; discussion concerned with sedan-type vehicles, having rear seat on which two adults can endure trip of reasonable length; market is divided into four price groups and makes of cars are listed; comments on economy, durability and safety.

Identification and Characterization of Rumble and Thud, E. S. STARKMAN. Paper No. 78T. Investigation, carried out by Univ. of California and California Research Corp. to determine interrelationships between rumble and engine operation and to indicate origin of audio-vibration or its precise character; effect of rumble on engine performance and mechanical condition. See also Engineering Index 1958 p. 88–9.

Ford Motor Company's Extra Heavy Duty Truck Engines, W. H. GAY, A. J. TOCCO. Paper No. S156. Interesting features with particular reference to general design objectives; performance specifications; how objectives were met.

Use of Radioactive Tracer Techniques to Determine Effect of Operat-

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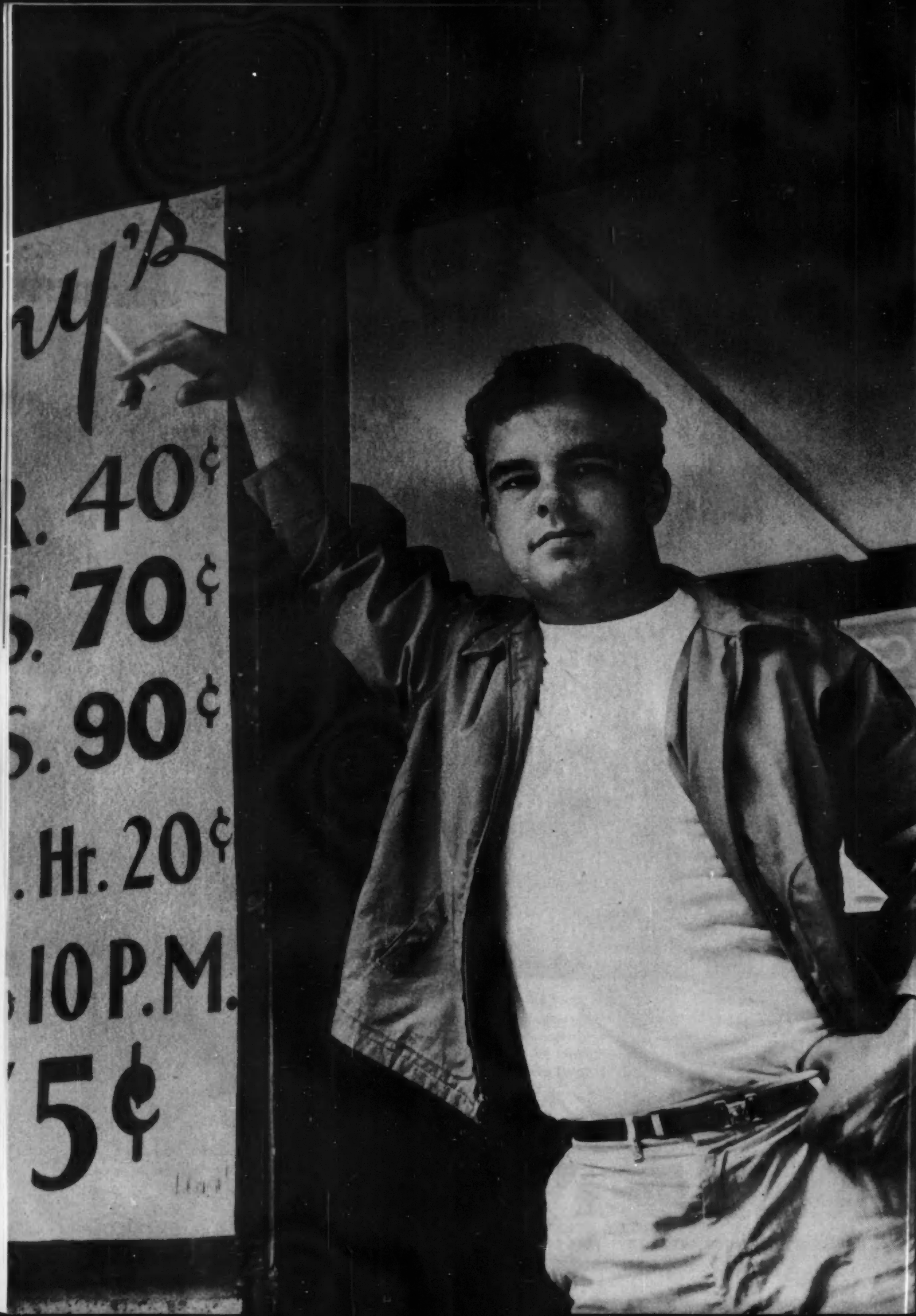

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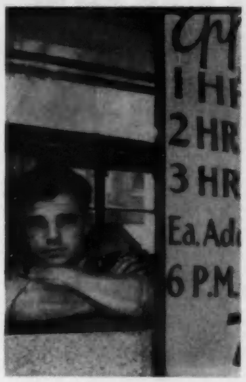

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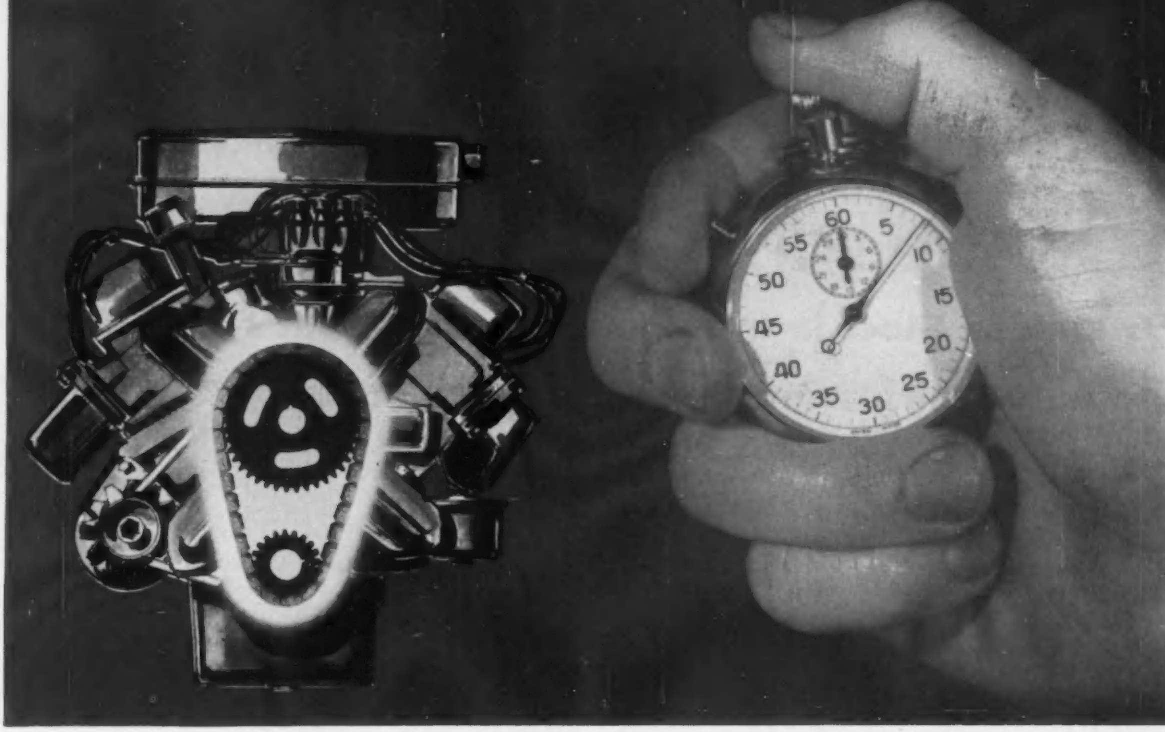

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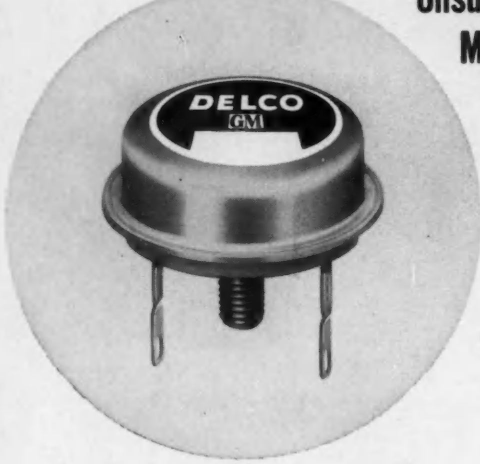

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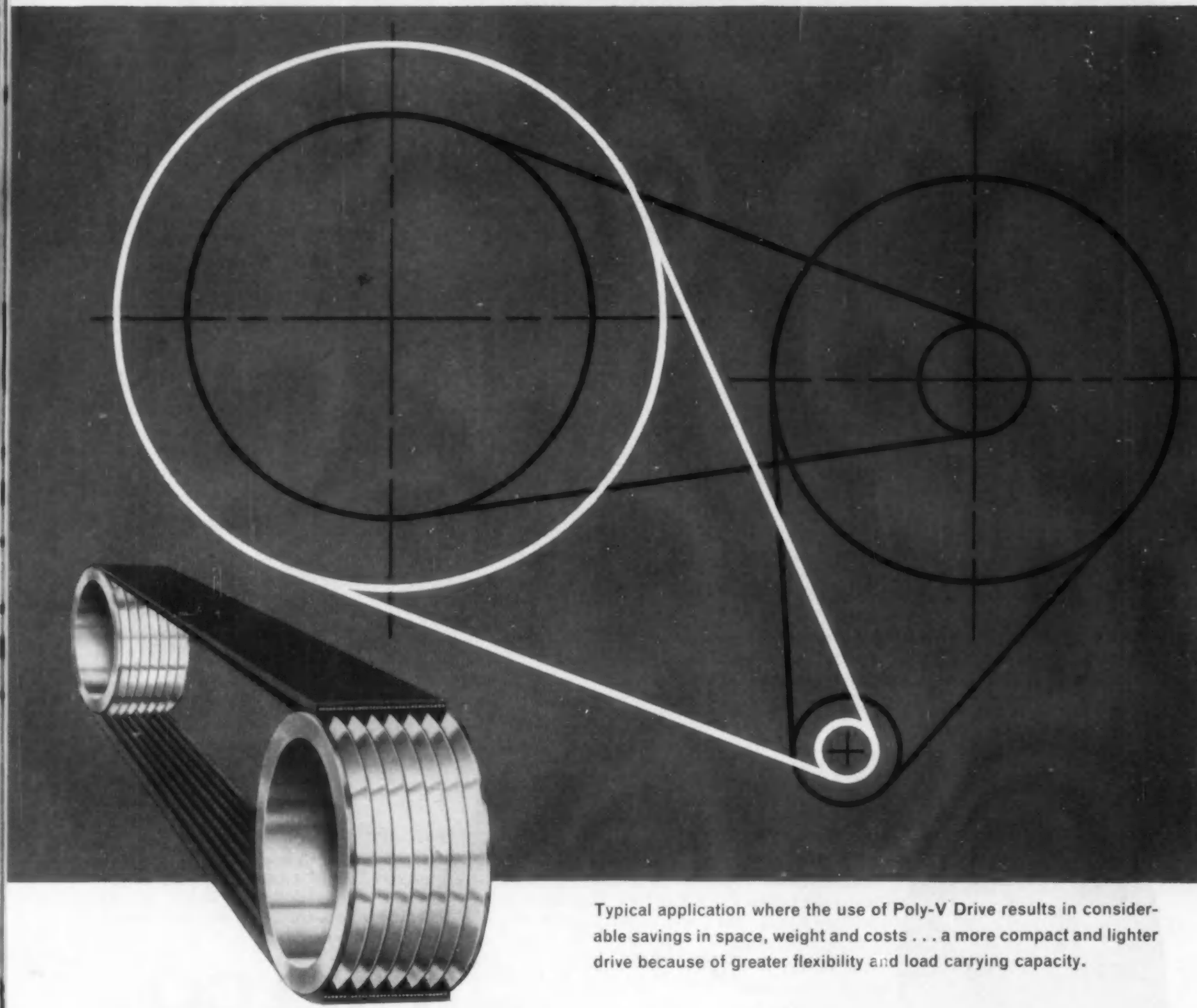

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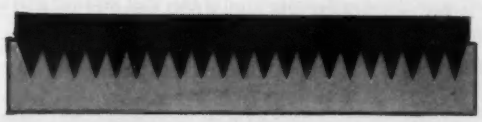

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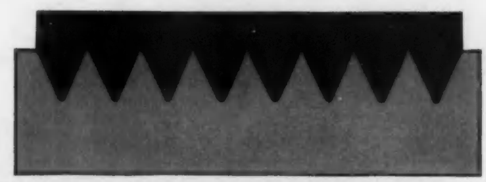

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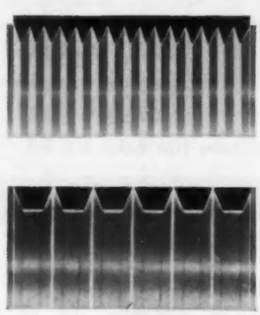

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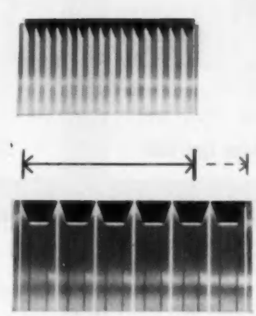

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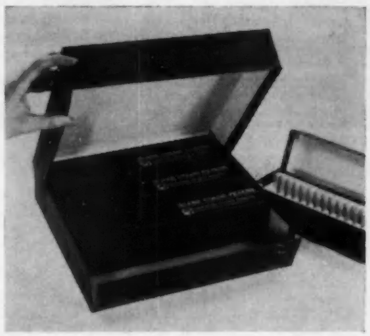

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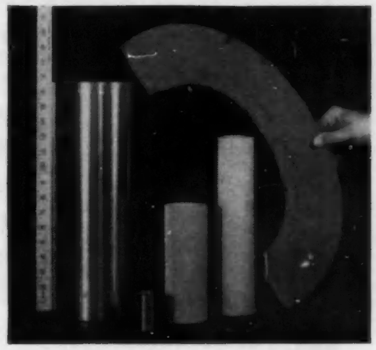

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SAE journal

For Sake of Argument

Consistency . . . .

"Consistencie's a jewell" said Jolly Robin-Roughhead way back in the days when English was spelled like that. . . . And maybe he was right. But there are plenty of reasons to doubt it.

It's difficult, for example, to find much virtue in being consistently wrong; and few of us are wise enough to be right consistently.

Then, too, who is harder to get along with than the man who prides himself on being consistent? Too often he's not a connoisseur of jewels. Instead, he may value as real gems of consistency what others tend to see as plain pig-headedness.

"Change your belief of things as often as you get new light," urges Adam Dickey, adding:

"We should not let vanity compel us to adhere to a proposition simply because we have taken a stand thereon. We should be willing to relinquish our former views and change our thoughts on any subject as often as wisdom furnishes us new enlightenment."

Brushing aside consistency as a goal need not enthrone inconsistency in its stead. The chap who prides himself on "being different" may end by being thoroughly consistent in his inconsistency. Striving always for off-beat responses, he may simply say and do the opposite of what most people would say or do under the same circumstances. He may strive so consistently to be unpredictable that he becomes easiest to predict.

Better to strive for wisdom, which Bertrand Russell defines as "a harmony of knowledge, will and feeling" than for consistency which Emerson saw as "the bugbear which frightens little minds."

Norman G. Shidle

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from SAE meetings, members, and committees

"STRANGE PARTICLES" is the name given to new classes of particles, the heavy mesons and hyperons — because their existence and properties were completely unexpected before their discovery. These "strange particles" exist for only tiny fractions of a second in high energy processes.

ENGINE POWER LOST AT HIGH ALTITUDES, TEMPERATURES — The total horsepower of a gasoline-driven engine is reduced 3½–4% for every 1000 ft increase in altitude above sea level. And one per cent of the total horsepower is lost for every 10 deg temperature rise above 60 F. Therefore, an engine rated at 100 hp will deliver only about 56 hp at 10,000 ft altitude and 107 F.

SIX BILLION ELECTRON VOLTS is required to make one proton-antiproton pair by letting a high-energy proton collide with a stationary one. This corresponds to the energy of the University of California Bevatron, which was the first man-made device capable of producing artificial proton-antiproton pairs.

Time and experience are not synonymous.

NYLON FLAT SPOTTING is the one characteristic of nylon tires that is retarding their acceptance as original equipment on new cars. This term refers to the flat spots that occur when a nylon-tire-equipped car stands for any appreciable time, such as overnight. So far, no remedy has been found . . . but they run out in several miles.

Customers have shown little concern, once they understand this, and compare it with the many advantages of nylon tires, according to C. R. McMillen of Goodyear. The car engineer is not satisfied, however, since it makes a poor impression on a new car buyer . . . hence, the pressure to eliminate nylon flat spotting.

BASIC ATMOSPHERIC DATA (pressure and temperature as related to altitude) will have to be corrected to reflect new and different data developed during the International Geophysical Year. Charts previously used to determine ambient pressure and temperature at a given altitude were found to be incorrect as a result of these studies and will have to be corrected. In other words, we didn't know as much about ambient pressures and temperatures at altitude as we thought we did.

The best way to be understood is to be understanding.

NEW INCH ADOPTED — The inch has only now been standardized by agreement between English-speaking (that is, inch-using) countries the world over. The new inch is about two-millionths shorter than the inch that has been standard in the U. S., and two-millionths larger than the British inch. It's a comment on the times that two parts in a millon is a really significant difference in hundreds of American industries.

ONLY MOLYBDENUM AND COLUMBIUM — of the four refractory metals available in quantity for structural applications — are being considered for sheet metal components today. Reason: Tantalum and tungsten — the other two — currently have overriding disadvantages.

Tantalum, the most ductile and easiest to fabricate, has a very low strength/weight ratio . . . and a very high cost. Tungsten has a low strength/weight ratio compared to molybdenum below 3000–3500 F; also its alloy development status is considerably behind both molybdenum and columbium. Recent experimental investigations of tungsten in sheet form do indicate it holds promise, however, for use over 3000–3500 F.

Worry grows lushly in the soil of indecision.

TRACTORS NOW AVERAGE 1 per farm in the United States. Something over 4,500,000 tractors are in use . . . But we have about 2,000,000 farms with *no* field tractors. The tractorless farms include sharecroppers, broiler farms, and others which don't need power for field operation . . . and thousands of small part-time or subsistence units which depend on workstock, garden tractors, or custom work.

OUTBOARDS' HORSEPOWER KEEPS RISING — The average horsepower of outboard engines sold in the United States was 20.7 hp in 1958 as compared to 9.0 hp in 1953. Sales rose from 463,000 in 1953 to 545,000 in 1958, with no pronounced peak year.

Table 1 — **Measured Values for Evaluating Alternate Methods of Loading a Falcon, Air-to-Air, Guided Missile**

		Checkout and Maintenance			Transportation			Storage					Loading							
	Factors	Equipment	Ease of Operation	Adaptability	Equipment	Compatibility	Adaptability	Equipment	Personnel Requirements	Combat Readiness	Ease of Operation	Hazardous Operations	Equipment	Combat Readiness	Ease of Operation	Complexity	Personnel Requirements	Total Equipment Requirements	Cost per Item	Total Cost
Systems	Weight		1.4	1.3		1.4	1.3		1.0	2.2	1.4	1.3		2.3	1.3	1.0	1.0			1.0
I Missile Transport Vehicle	I. A) MTV Overhead Racks One Hoist/MTV	MTV	39	40	MTV	4.5	9.0	MTV, Overhead Racks and Hoist	2.0	4.3	22	1.0	MTV and Hoist	7.6	73	61	4.0	* MTV'S Overhead Racks Storage Magazines Hoists Missile Adapters	*	1,380,000 2,992,000 9,680,000 2,760,000 552,000 16,884,000
	B) MTV Overhead Racks One Jack/MTV	MTV	49	45	MTV	4.5	9.0	MTV, Overhead Racks and Jack	2.0	3.8	21	1.0	MTV and Jack	8.3	87	63	4.0	MTV'S Overhead Racks Storage Magazines Jacks Missile Adapters Maintenance Stands		1,380,000 2,992,000 9,680,000 3,312,000 552,000 27,000 17,463,000
	C) MTV Level Racks One Hoist/Aircraft	MTV	39	40	MTV	4.5	9.0	MTV and Level Racks	2.0	2.4	10	0	MTV and Hoist	7.6	73	61	4.0	MTV'S Level Racks Storage Magazines Hoists Missile Adapters		1,380,000 864,000 12,000,000 780,000 1,620,000 16,644,000
	D) MTV Level Racks One Jack/MTV	MTV	49	45	MTV	4.5	9.0	MTV and Level Racks	2.0	2.4	10	0	MTV and Jack	8.3	87	63	4.0	MTV'S Level Racks Storage Magazines Jacks Missile Adapters Maintenance Stands		1,380,000 864,000 12,000,000 3,312,000 1,620,000 27,000 19,203,000
II MF-9	II. A) MF-9 Overhead Racks	MF-9 and Maint. Stand	49	40	MF-9	4.5	12	MF-9 and Overhead Racks	2.0	4.1	24	1.0	MF-9	8.5	76	63	4.0	MF-9'S Mod Kits Overhead Racks Storage Magazines Maintenance Stands Missile Adapters		5,796,000 1,932,000 2,992,000 9,680,000 27,000 552,000 20,499,000
	II. B) MF-9 Level Racks	MF-9 and Maint. Stand	49	40	MF-9	4.5	12	MF-9 and Level Racks	2.0	2.4	10	0	MF-9	8.5	76	63	4.0	MF-9'S Mod Kits Level Racks Storage Magazines Maintenance Stands Missile Adapters		5,796,000 1,932,000 864,000 12,000,000 27,000 1,620,000 22,239,000
III MJ-1	III. MJ-1 MHU-12/M Level Racks	MHU-12/M and Maint. Stand	49	50	MHU-12/M	7.0	16	MHU-12/M and Level Racks	3.0	2.4	10	0	MHU-12/M and MJ-1	8.3	83	50	4.0	MJ-1'S MHU-12/M'S Mod Kits Level Racks Storage Magazines Maintenance Stands Missile Adapters		2,340,000 3,036,000 2,001,000 864,000 12,000,000 27,000 1,620,000 21,881,000

* Not listed due to classification

How to optimize a **Missile**

Based on paper by **Byron A. McDonald**
Hughes Aircraft Co.

A SYSTEM of factorial analysis has been developed by Hughes Aircraft to optimize the ground support equipment for the Falcon, air-to-air, guided missile.

All factors, especially those which relate to the requirements of the using command, must be considered in an analysis. If the common factors alone were satisfied, a poor form of standardization would result. Some of the operational requirements to be met in the development of the Falcon system were:

1. Mass loading of all alert aircraft within a definite time limit.
2. Several aircraft alert requirements.
3. Loading aircraft at turn-around.
4. Use of existing and restricted storage and maintenance buildings.
5. Adherence to military safety regulations.
6. Minimizing the use of skilled airmen.

Fig. 1 shows the general outline of the analysis method used. Five to seven systems are all that can be handled in a reasonable time, that is, two to four man-months. Here, system covers equipment needed to support a missile from stockpile to on-aircraft and return.

The major areas of support are listed across the top of Table 1 as checkout and maintenance, transportation, storage and loading. Shipping is omitted to reduce the complexity of the presentation. Factors selected as pertinent to the case, and for each major area, are listed diagonally. Factors constant for all systems, such as squadron size and armament load, are unlisted. A weight has been assigned to each factor to denote relative importance and totals

Table 2 — **Factorial Measure of Values Shown in Table 1 Adjusted for Weight and Made Nondimensional. Adding the Factors Together Gives a Grand Total for Each Equipment System and the Lowest Score Indicates the Best**

		Checkout and Maintenance			Transportation			Storage					Loading						
	Systems / Factors	Equipment	Ease of Operation	Adaptability	Equipment	Compatibility	Adaptability	Equipment	Personnel Requirements	Combat Readiness	Ease of Operation	Hazardous Operations	Equipment	Combat Readiness	Ease of Operation	Complexity	Personnel Requirements	Total Cost	Total Points
I Missile Transport Vehicle	I. A) MTV Overhead Racks One Hoist/MTV	MTV	1.40	1.30	MTV	1.40	1.30	MTV, Overhead Racks and Hoist	1.00	3.94	3.08	1.30	MTV and Hoist	2.30	1.30	1.22	1.00	1.01	21 55
	B) MTV Overhead Racks One Jack/MTV	MTV	1.76	1.45	MTV	1.40	1.30	MTV Overhead Racks and Jack	1.00	3.48	2.94	1.30	MTV and Jack	2.51	1.55	1.26	1.00	1.05	22.00
	C) MTV Level Racks One Hoist/Aircraft	MTV	1.40	1.30	MTV	1.40	1.30	MTV and Level Racks	1.00	2.20	1.40	0	MTV and Hoist	2.30	1.30	1.22	1.00	1.00	16 82
	D) MTV Level Racks One Jack/MTV	MTV	1.76	1.45	MTV	1.40	1.30	MTV and Level Racks	1.00	2.20	1.40	0	MTV and Jack	2.51	1.55	1.26	1.00	1.15	17.98
II MF-9	II. A) MF-9 Overhead Racks	MF-9 and Maint. Stand	1.76	1.30	MF-9	1.40	1.73	MF-9 and Overhead Racks	1.00	3.76	3.36	1.30	MF-9	2.58	1.35	1.26	1.00	1.23	23.03
	B) MF-9 Level Racks	MF-9 and Maint. Stand	1.76	1.30	MF-9	1.40	1.73	MF-9 and Level Racks	1.00	2.20	1.40	0	MF-9	2.58	1.35	1.26	1.00	1.34	18.32
III MJ-1	III. MJ-1 MHU-12/M Level Racks	MHU-12/M and Maint. Stand	1.76	1.62	MHU-12/M	2.18	2.32	MHU-12/M and Level Racks	1.50	2.20	1.40	0	MHU-12/M and MJ-1	2.51	1.48	1.00	1.00	1.32	20.29

Ground Support System

for manpower, equipment, and equipment cost are listed.

It all adds up

If a unit of measure is determined for each factor, the magnitude of each can be determined for each system. One can then compare all of the systems relative to each factor, but the factors cannot be added together horizontally to get a grand total for each system until the factors are made nondimensional and adjusted for weight.

Table 2 shows the factorial measure from Table 1 adjusted for weight and made nondimensional. This is accomplished by multiplying the measured value of each factor, as shown in Table 1, by the relative weight, then dividing by the lowest values for each factor. It is now possible to add the factors together and get a grand total for each equipment system. The lowest total, like a golf score, should indicate the best system of those investigated.

Space forbids giving detailed steps to answer the questions as to choice of appropriate factors, how to measure and weigh them, but a clear understanding of how they are done is essential.

Some merits of the analysis

With the facts down in black and white, it is possible to see how each system compares and why one system appears better than the rest. If it is desired to use an existing piece of equipment or introduce a unique procedure, the gains or losses in so doing can be measured quickly and accurately.

To Order Paper No. 97V ...
... on which this article is based, turn to page 6.

Electric Drives are Practical for Off-Highway Vehicles

Based on paper by

H. J. McLean and H. Vitt

General Electric Co.

THE CONCEPT of an electric motor mounted inside the rim of a large wheel provides new standards of flexibility and performance. It also offers weight and cost reductions over more conventional electric drive schemes that make the advantages of electric power application to a number of wheels and increased braking capacity economically feasible in large off-highway vehicles. Moreover, the motorized wheel vehicle will easily fit into established operating and maintenance patterns.

A heavy-duty traction motor drive has been designed that eliminates the need for mechanical drive lines, differentials, and hydraulic torque converters. Four of these motors can deliver the full output of engines rating up to 1600 hp for traction. The system is designed to provide 60% adhesion on all wheels at standstill and full horsepower utilization over most of the speed range to a maximum of 35 mph. It serves to make electric drive a practical means of economically providing power on every wheel of a single-engine, tractor-type, off-highway vehicle. In fact, power for traction can now be applied to each and every wheel of any off-highway vehicle anywhere a set of flexible cables can be run.

One method of reducing operating expense is to increase the vehicle payload. Here the weight and space requirements of the drive are important. Materials and space should do double duty wherever possible to minimize the tare weight of the vehicle. Electric drive is well suited for this, since the size and shape of the magnet frame required for a traction motor easily conforms to the large, relatively unused space available inside the rim of off-highway tires. Hence weight and space can be most efficiently utilized by placing the traction motor in this space and using its frame as the axle of the wheel.

This scheme eliminates the conventional axle, shortens drive lines, and makes a compact driving unit. The motor is also freed of limitations imposed by vehicle design, making it easily adaptable to any large, off-highway vehicle. This configuration also places the items needing most frequent maintenance in the most accessible position — on the outboard end of the wheel rim.

the motorized wheel

The motorized wheel is basically a heavy steel barrel joined to a large mounting flange. The motor and brake are mounted within this heavy steel barrel, which doubles as the vehicle wheel axle and the motor magnetic belt, or magnet frame (Fig. 1). A d-c, series-wound motor of rugged transportation-type design is used, having the pole pieces for the field structure bolted to the inside of the hollow axle. The armature is carried on a concentric shaft which drives the power gear train through a floating pinion. An airplane-type disc brake is mounted on the commutator end of the shaft.

The wheel bearings are placed around this axle (or magnet frame). They are large diameter taper roller bearings, similar to the type used in steel mill rolls under heavy load and shock. The size used can sustain the heavy loads imposed on a motorized wheel, and still have capacity for long life.

The mounting flange to which the motor barrel is attached also forms part of the gear case structure. The motor armature is splined to a short sun pinion shaft whose teeth engage three large gears placed in

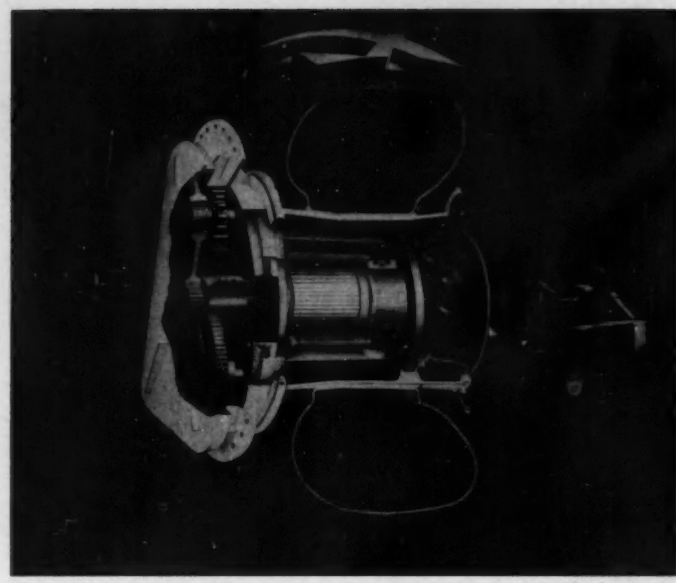

Fig. 1—Motorized wheel, showing details of motor and gear train.

planetary fashion 120 deg apart. This first stage of reduction is located on the vehicle side of the mounting flange wall in a recess in the vehicle body. Each of these three planet gears is mounted on a pinion stub shaft whose bearings are in the fixed motor mounting flange. These fixed planet pinions emerge through openings in the flange-gear case wall to drive an internal ring gear, thus accomplishing the final reduction. The ring gear, in turn drives the wheel rim through a spline connection. The mounting flange supports the wheel loading through the magnet frame; provides a means of attaching the motorized wheel to the vehicle; and acts as part of the gear case. The tire, rim, axle, motor, gearing, and brake form one complete unit. In case of major motor or gear failure, the entire motorized wheel unit can be readily replaced in the field and the vehicle kept in operation.

power gear train

When the d-c series-wound traction motor, with its inherent characteristic of high torque at low speeds is coupled with a high gear reduction, tremendous starting torque can be generated. To translate the high torque generated by the motor to that required by the vehicle, a gear reduction of approximately 40 to 1 is employed. This provides vehicle speeds up to 35 mph and a maximum tractive effort of 32,400 lb, corresponding to 60% adhesion with 54,000 lb on the 44.5-45 tire. With full horsepower utilization over most of the speed range, this transmission provides a highly efficient, smooth flow of power to all wheels.

To transmit these high torques through a single gear of reasonable face width would result in excessive tooth loads, so the obvious solution was to use a modified compound planetary system, with output torque provided by three pinions of normal face width. The planet gears are not allowed to rotate as planets around the sun pinion, but are "fixed in space" by building them into the motor frame. The planet carrier is eliminated and the fixed planets drive a movable ring gear. The gearing was placed on the inboard or vehicle end of the motor.

With such high torques to be transmitted it is imperative that each gear tooth carry its share of the load. Unequal load distribution among the gears would result in premature tooth failure and short gear life.

The high speed gearing is composed of an 18-tooth, 3.85-diametral pitch sun pinion, driving three 87-tooth gears. This tooth combination provides a hunting tooth, thereby improving life and reducing gear noise. Equal load distribution between the gears is accomplished by having the sun-pinion float in its meshes. The three 120-deg spaced meshes support the gear end of the sun pinion shaft. Tooth-separating forces demand the pinion equalize the loads on itself and thus divide the load equally between the gears. At each tooth engagement the pinion runs on a different center, depending on tooth-spacing accuracies, profile error, and other variables. This center is dictated by the resultant of the three force vectors from the gear meshes. The floating action of the sun pinion shaft is accomplished by a sliding-fit splined connection between it and the motor armature.

In the low-speed, or final reduction the tooth loads are higher, and hence it is the more critical of the two meshes. The 15-tooth 3.2-diametral pitch pinions mesh with a 111-tooth internal gear. Here the problem is a little more difficult. The ring gear must be designed to: 1. float sufficiently to equalize the loads of the three planet pinions; 2. engage the

Electric Drives are Practical for Off-Highway Vehicles

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Fig. 2 — Airplane-type disc brake used for parking and emergency service.

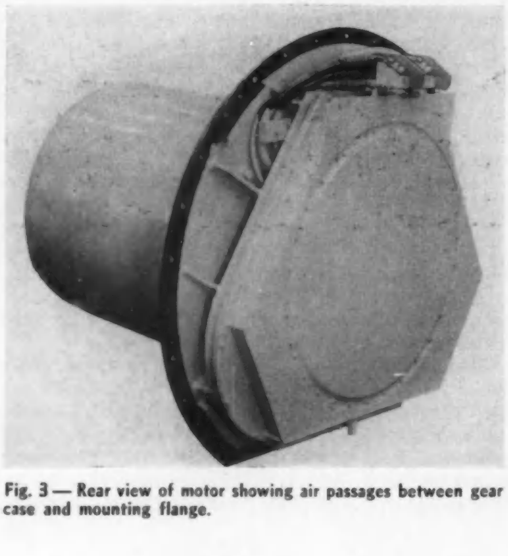

Fig. 3 — Rear view of motor showing air passages between gear case and mounting flange.

wheel rim positively to transmit driving torque; and 3. not transmit wheel or axle loads through the planetary gear meshes and thus overload both gearing and gear bearings.

The splined drive ring attached to the rim is designed to help fulfill these requirements. Its cylindrical shell has a section flexible enough to allow distortion by tooth-separating forces and to prevent transmission of heavy axle loads to the gearing. Thus the ring gear floats by distortion, both of itself and the splined drive ring, to equalize tooth loads. This built-in flexibility makes the gear train self-adjusting to the gear loads resulting in improved performance and increased gear life.

lubrication

The gearing and bearings are splash-lubricated by oil, except for the motor armature and outer wheel bearings, which are grease-lubricated. Essentially, the splash-lube system operates by lifting oil to the top of the gear case by means of the two lower planet gears. On its return path the oil is directed to appropriate locations by means of channels and gutters. One gutter feeds oil to the ring gear which carries it to the top of the low-speed gear case for a second cycle of lubrication.

An oil sump located beneath the two lower planet gears also serves to collect wear particles and heavy sediment that becomes mixed with the oil. This sump is covered by a plate with nozzle-like openings pointing downward, thus forming a screen that creates a dead oil area and serves to keep particles which may damage bearings or gearing out of the oil circulation.

brakes

The motorized wheel has two brake systems. The primary system is the electric or dynamic brake. The secondary system consists of a mechanical airplane-type disc brake on each motor.

Normal service braking is performed by the electric brake. This system is capable of developing a braking effort of approximately three times the available traction horsepower, and has no wearing parts, such as linings or drums that require periodic replacement.

The secondary system is used as a parking brake and as an emergency brake in case of engine failure. While it may also be used simultaneously with the dynamic brakes to develop an unusually high retarding force, it is not intended for use as a day-to-day service brake.

The secondary brake is composed of two main elements (Fig. 2) — a flat slotted disc splined to the motor armature shaft, and a double-acting hydraulic cylinder assembly rigidly bolted to the motor frame. The two pistons are headed by a brake lining material which in operation act in a C-clamp action on opposing sides of the brake disc. The brake cylinders are hydraulically operated, either directly, or from an air-over-hydraulic power cluster. Since this brake is used for parking, it may be desirable to provide an accumulator to maintain brake cylinder pressure in the event of slow air system leakage. This would be particularly desirable if the vehicle were to be parked overnight on a steep grade.

The brake operates smoothly since it is not self-

energizing. The braking action is transfered to the wheel with no danger of damage to the gears.

This disc-type friction brake has an advantage over the conventional drum and shoe brake in that there is no brake fade. Since the linings bear against the sides of the disc the expansion caused by heating will not affect the contact area as in a drum brake. The disc is of a special alloy, designed to operate under normal conditions at about 600 F with a maximum operating temperature of about 1000 F. Maximum kinetic energy capacity is 2,890,000 ft-lb per brake for any one stop. To raise the disc to the normal operating temperature requires 1,735,000 ft-lb, more than enough energy to bring a 4-motor, 100-ton vehicle to a stop from 30 mph. Torque developed by the brake is 20,000 in.-lb at 590 psi hydraulic pressure.

The brake disc is situated in the motor cooling air stream, thus helping to keep operating temperatures low. Air from the motor impinges directly upon the inner side of the disc. The outer side is cooled by a radial vane-type fan cast integral with the brake disc mounting hub. This cooling enables the operator to reapply the brakes much sooner than if no artificial cooling were used.

The brake cylinder and disc are easily serviced by removing the motor hub cap. Brake shoes need only be inspected during the regular monthly motor brush inspection.

ventilation

The concentration of so much power in a relatively small space and weight is made possible largely through the use of high-temperature insulation and generous ventilation, in accordance with modern traction equipment design practice.

Because of the location of the gear case, introducing air to this motor was a major design problem. The method used was to blow air into the motor by going under the gear case, mounting the motor in a plenum chamber built into the vehicle.

This is accomplished by welding the motor barrel to a mounting flange and attaching the gear case to the rear or inboard side of the flange, raising the gear case up free of the flange by means of ribs or

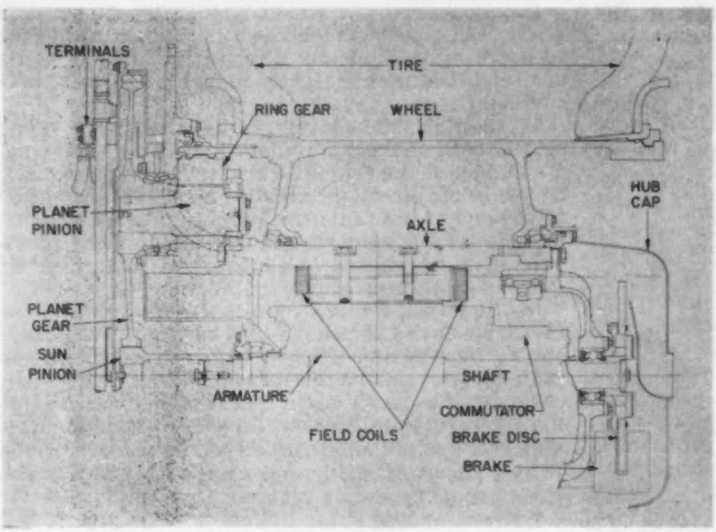

Fig. 4 — Simplified longitudinal section of motorized wheel.

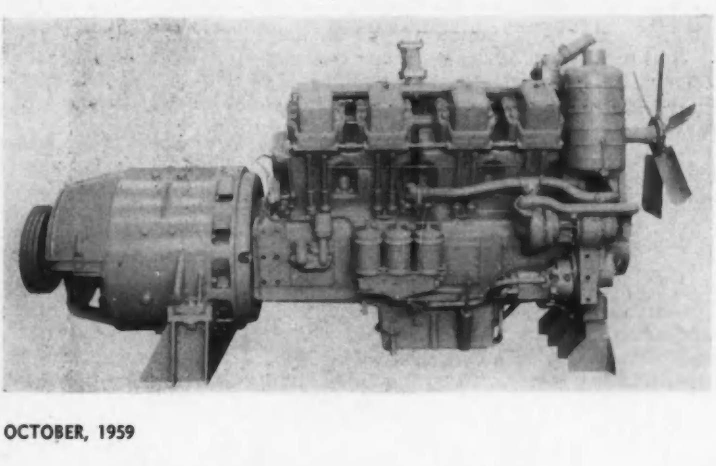

Fig. 5 — Representative engine-generator set.

Electric Drives are Practical for Off-Highway Vehicles

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stilts, as shown in Fig. 3. The motor is then bolted to a cavity on the vehicle, to which air is introduced at another point. The air flows over the gear case, around the sides, under the gear case, and through the motor field and armature, over the brake disc, and out through the hub cap.

This design has the following advantages:

1. No external ducting need be connected to the motor, all air connections being made automatically when the motor is bolted to the vehicle.

2. Cooling of the gear case itself by air flow over the entire back and about half of the front, thus carrying away the heat buildup in the high speed gearing and cooling the lubricating oil reservoir located in the gear case.

3. No ducts run through the gear case, eliminating a potential source of oil leakage and keeping the oil capacity of the gear case at a maximum for heat dissipation purposes.

The air outlet is spray or splash-proof and with a 44.5-45 tire allows the vehicle to negotiate water 52 in. deep without danger of flooding the motor. Application of watertight covers to the air outlets would permit the vehicle to operate for short periods of time with the motors completely submerged. For continued submerged operation a snorkel arrangement could be developed to keep the motor from overheating.

interesting design points

In designing a machine of this size and complexity many problems, some obvious and some almost obscure, must be solved. All parts must work toward providing a smooth flow of power from the electricity fed into the motor to the traction at the tire tread. All components (Fig. 4 shows a simplified longitudinal section) must be so related that not only will the main drive line function properly, but also all its supporting and aiding parts will contribute toward the main task of providing smooth, reliable tractive effort.

Examples of a few of these related components and their functions will serve to illustrate their importance.

In this design of wheel, oil seals of larger diameter than usual are employed. The gear case oil seal, with a sealing diameter of 42½ in., statically must seal against a head of approximately 8 in. of oil, and dynamically against 4 in. of oil. The inboard wheel-bearing seal, although sealing against oil, is only bathed by the oil fed to the wheel bearing, hence is not required to have the same sealing capacity as the gear case seal.

During the design of the production model of this wheel, considerable time and effort were expended in investigating seal configurations and effects of variables on seal performance. As a result a seal housing design has been developed which gives satisfactory performance under service conditions. Sealing is effected by a double seal arrangement; one rubbing seal to keep oil in, and another in series with it to keep dirt out.

Another item requiring consideration is the effect of the expansion and contraction of the air under the rim where it is subject to wide temperature variations. With a 45-in. rim there is a volume of about 14 cu ft of air in this space. When the vehicle is shut down or left idle for a period of time, this air space will approximate ambient temperature. During operation, however, it is heated by the motor frame, the hot oil in the gear case, and the hot air in the tire. Since the volume enclosed remains constant (Fig. 4), a rise of temperature would tend to develop pressure in the enclosed space. When the motor cools off the process will be reversed, and a respiratory action would tend to result. This condition is relieved by a small hole drilled through the motor frame which serves as a pressure equalizer.

Location axially of the sun pinion shaft was another design problem. Since this shaft must be free to move radially in any direction it chooses at its gear end it cannot be rigidly connected to the armature shaft.

To restrict axial movement in one direction, the spline teeth of the sun pinion shaft impinge against a shoulder of the armature shaft. To hold it axially in the other direction, an alloy steel plate is bolted to the end of the armature shaft to provide a thrust surface for the spline teeth. The end of the armature shaft is relieved to support the plate near its outer edge, thus providing ample follow-up to maintain the bolt tightness. Since the retaining members are either attached to, or a part of the armature shaft, there is no relative motion between the sun pinion shaft and the retaining parts.

This design has a distinct advantage over absorbing the thrust by a thrust bearing or washer against which the shaft must rub at considerable velocity. It also allows assembly and disassembly of the sun pinion shaft by simply removing one bolt.

By making the shaft hollow to allow use of the plate retention device, (Fig. 4) an easy, effective means was provided for lubrication of the spline. Oil is introduced into the hollow pinion and centrifugally forced through the spline teeth.

the electric drive system

Electric power for the wheel motors is provided by an engine-generator set. The generator is usually designed to mount directly on the engine as shown in Fig. 5. An adapter is used to assemble the generator frame to the engine, and the armature is driven by the engine flywheel through a disc coupling that is stiff radially and torsionally, but soft axially.

To Order Paper No. 92T . . .
. . . on which this article is based, turn to page 6.

How to Improve Soil Compacting Equipment

Suggestions gleaned from a poll of contractors and supervisors

Based on paper by

E. Miller Smith

S. J. Groves & Sons Co.

A PIECE of compacting equipment may be a complete failure in one location with one type of soil and be a great success in another location where the soil is different. Nevertheless, there is room for improvement in compacting equipment regardless of specific soils.

To find out what the dirt mover thinks these improvements should be, a poll was taken of the men who supervise construction under Grove company management. Outside contractors were also queried to make the findings representative of the earthmoving industry as a whole. The Grove company alone operates about 175 pieces of compacting equipment and in the past two seasons has worked on projects in some 20 states.

What earthmovers want

There was an almost universal request from those contacted to see some standardization of equipment.

Excess equipment stands idle on all projects. Due to the experimentation necessary to prove just what type will produce soil densities by the fastest and cheapest methods, a wide selection of equipment must be available to insure some efficiency.

The opinion is widespread that some effort should be made to develop rubber tired and vibrating steel drum rollers with more coverage, that is, wider compaction widths to fit the widths of the layers spread. This might apply more to granular materials than to common earth soils. Towing the equipment in tandem, or in a staggered manner, does give the coverage, but more efficiency could be obtained if this could be concentrated in a single unit.

There is need for a power unit that will move heavy rubber tired compactors more easily, particularly in the 50-, 100-, up to 200-ton capacity range. Such a unit would greatly expand the use of these rollers, perhaps for both earth soils and granular material.

A leading soil consultant strongly advocates the use of extremely heavy rubber roller tired rollers for the compaction of all types of soils. He recommends developing an all-purpose roller on large rubber tires with an adjustable weight range from 20 to a possible maximum of 200 tons. It might be made so that the width of the roller could be changed in the field to fit individual conditions by adding or removing sections in increments of, say, one tire width at a time. There is also need for a new method for propelling the unit.

Moisture control

Moisture control is important to the dirt mover and some supervisors think the time may not be so far off when someone will devise a process, requiring equipment, which will add or remove moisture from layers of soil as they are placed, quickly and economically. Moisture is one of the most important factors in soil compaction and it must be considered and controlled if a proper job is to be done. This means that there must be persons properly trained to make compaction tests and they are scarce.

Several of the state highway departments have rewritten or are rewriting their specifications and the trend is toward making specified densities the basic requirements without regard to depth of layers, types of equipment or number of pieces to be used. If density does become the sole requirement, then the earthmoving industry would request that some thought be given to standardization of the methods for determining soil densities. This would end the confusion caused by differences in standards and methods of testing and help both the contractor and equipment manufacturer to approach the problems of soil compaction with more efficiency and economy.

To Order Paper No. 89V . . .
. . . on which this article is based, turn to page 6.

Engine Rumble

doesn't have to be a barrier

Careful selection of oils and fuels will

higher engine efficiencies to be reached without

Based on paper by

R. F. Stebar, W. M. Wiese, and R. L. Everett

General Motors Research Laboratories

ENGINE RUMBLE is caused by abnormal combustion which is directly related to the presence of combustion chamber deposits. Any factor which affects deposit composition affects rumble. Wide differences in engine rumble requirements are witnessed when using different commercial crankcase oils. Rumble requirements of high-compression cars can be reduced, however, through high concentrations of phosphorus in the gasoline to modify deposit characteristics.

Certain engine design and operating variables affect the occurrence of rumble through their influence on the combustion process. The rumble requirement of an engine is increased if:

1. Compression ratio is increased.
2. Air-fuel ratio approaches best power mixtures.
3. Inlet air humidity is decreased.
4. Inlet air temperature is increased.
5. Engine load is increased.
6. Engine speed is increased.

Most important, however, is that higher compression ratios and correspondingly higher engine efficiencies can be reached without objectionable rumble if oils and fuels are carefully selected.

Crankcase oils — effect on rumble

During normal engine operation, crankcase oil is drawn past the piston rings and through the valve guides into the combustion chamber of an engine. Although the amount of oil consumed in this manner is small, the effect on deposit ignition and, hence, rumble occurrence is extremely important.

Rumble Measurement Technique

THE OCCURRENCE of rumble as described in this article was measured through the use of leaded isooctane-benzene (LIB) reference fuels. (These reference fuels were originally proposed by the Coordinating Research Council for use in deposit ignition studies). The LIB reference fuel series is made up of blends of leaded isooctane in leaded benzene. Each blend contains 3 ml tel per gal. The LIB number of the individual blends corresponds to the percentage of leaded isooctane in the blend.

Since isooctane has very high resistance to deposit ignition and benzene has very low resistance, blends of the two fuels provide a series of reference fuels having varying deposit ignition resistance. Reference fuels were blended in 10% increments.

The LIB fuels are used to measure the deposit ignition or rumble requirement of an engine in much the same manner as the octane scale is used to measure antiknock requirement. The rumble requirement of an engine is defined as the LIB number of the fuel which produces trace rumble. Knock is not encountered with the LIB fuels because all blends have Research and Motor octane ratings of 115 or higher.

to higher compression ratios

permit higher compression ratios and correspondingly objectionable rumble.

Certain oils form combustion chamber deposits which cause more rumble than other oils.

The relative contribution of commercial oils to the occurrence of rumble was explored in two 1959 production V-8 engines at 10:1 compression ratio using a dynamometer test technique. Equilibrium combustion chamber deposits were accumulated for each oil on a light-duty deposit build-up schedule. A commercial gasoline (Fuel B, Table 1) which contained 0.22 theories of phosphorus was used throughout the oil evaluation tests. (One theory of phosphorus is the theoretical amount required to convert all of the lead in the fuel to lead orthophosphate.

Engine rumble requirements were determined periodically at 3000 rpm — full throttle. Data for two oils are shown in Fig. 1. Engine rumble requirements are shown as a function of deposit accumulation time. The individual requirements between 100 and 200 test hours were averaged to provide a stabilized rumble rating for each oil; the higher this rating, the more undesirable the oil with respect to rumble. For example, use of the 20W oil rated at 80 LIB is more likely to cause engine rumble than use of the 10W-30 oil rated at 45 LIB numbers. Reproducibility of test results was considered satisfactory since rumble ratings of these two oils repeated within 5 LIB numbers in duplicate tests.

The important influence of crankcase oils on engine rumble is shown in Fig. 2. Included are data for ten commercial MS oils of 20W, 10W, and 10W-30 SAE viscosity classifications. The rumble ratings of these oils differed widely. For the five 20W oils, rumble ratings ranged from 65 LIB for Brand D to greater than 100 LIB numbers for Brand A. Ratings for the four 10W-30 oils ranged from 15 LIB for Brand A to 55 LIB for Brand E. The one 10W oil tested, Brand D, was rated at 55 LIB numbers. In every case the 10W-30 oils had lower rumble ratings than did the 20W oils.

Results from laboratory analyses of the ten oils

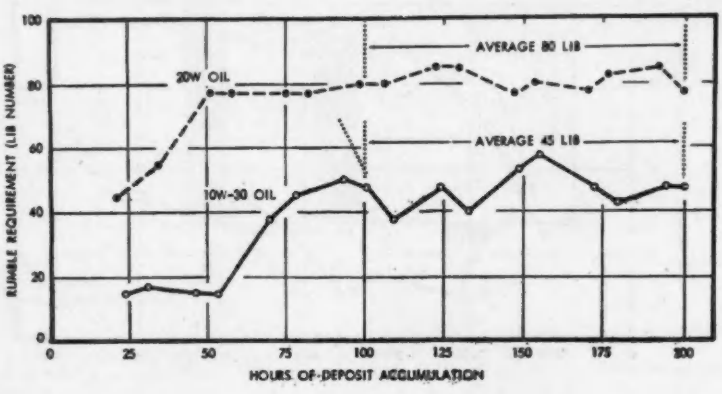


Fig. 1 — Engine rumble requirements during deposit accumulation. 10:1 compression ratio; 3000 rpm; full throttle; engine dynamometer.

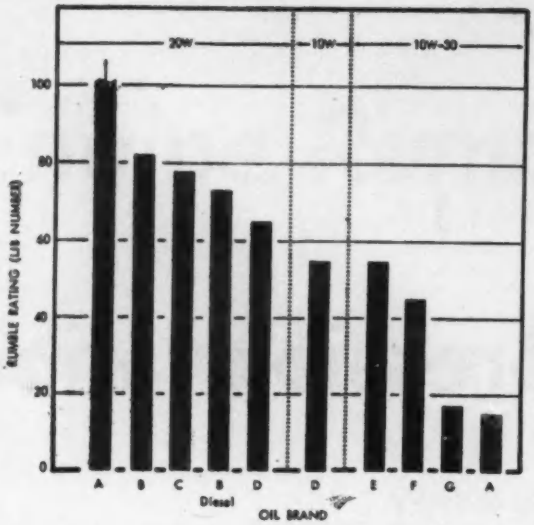


Fig. 2 — Rumble ratings of commercial MS engine oils. 10:1 compression ratio; 3000 rpm; full throttle; engine dynamometer.

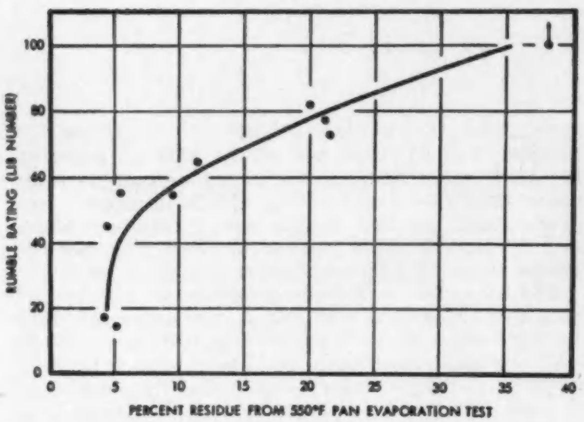


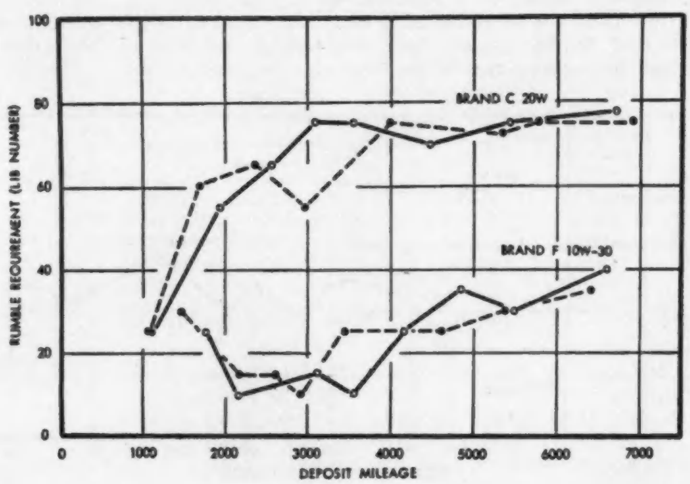
Fig. 3 — Correlation of oil rumble ratings with pan evaporation data.

indicated a correlation between rumble ratings and oil volatility characteristics. The best correlation was found when volatility was expressed in terms of per cent residue from a 550 F circulating-air pan evaporation test. This correlation is shown in Fig. 3. In general, the higher the per cent residue, the higher is the rumble rating of the oil or, in other words, oils having a high percentage of residue are more likely to cause engine rumble. The pan evaporation test or a similar test may offer a means of detecting oils which will produce excessively high engine rumble requirements.

A road test evaluation of two oils, Brand C 20W and Brand F 10W-30, verified the rumble ratings of these oils determined by the laboratory tests. For the road tests, four cars having engines of the same make and model as used in the dynamometer tests were operated in company transportation service. The factory-fill oil was drained at approximately 1000 miles, and thereafter two cars were operated on Brand C 20W and two on Brand F 10W-30 oil. Engine rumble requirements were measured at approximately 500-mile intervals. The requirements were determined at 3000 rpm — full throttle. Engine speed was held constant with the brakes.

Results of the road tests are presented in Fig. 4. Engine rumble requirements are shown as a function of car mileage. After 4500 miles the cars operated on Brand C 20W oil had rumble requirements of approximately 75 LIB numbers while the cars using Brand F 10W-30 oil had requirements of approximately 35 LIB numbers. A comparison of these road test results and the laboratory results . . . indicates that both tests rank the oils in the same order; furthermore, the rumble requirements of the cars

Fig. 4 — Road tests to verify dynamometer ratings of oils.



agreed reasonably well with those obtained for the laboratory engines.

Fuels — effect on rumble

The fuel used in an engine can affect the occurrence of rumble in two ways: first, through the deposits formed in the combustion chamber when the fuel burns, and second, through the inherent resistance of the fuel to deposit ignition when exposed to the high temperatures and pressures in the cylinder during the compression stroke. Both of these effects must be considered when evaluating the merits of a gasoline.

Fuel Contribution to Deposits

Fuels as well as oils affect the type of deposits formed in the combustion chamber. The deposits formed when using certain types of fuel are more likely than others to cause deposit ignition which can result in rumble. It has been shown by past investigations that fuels containing very high-boiling hydrocarbons or certain heavy aromatic hydrocarbons form deposits which are more prone to cause deposit ignition and rumble than other fuels. Investigations have also shown that gasoline additive treatment has a marked effect on the deposit ignition tendency of the deposits formed.

Fig. 5 shows the variation in engine rumble requirement that can result from the use of different types of fuel. These data were obtained on an engine dynamometer using the same 1959 production engine and test procedure as was used for the engine oil tests. Three different fuels were tested with a commercial 10W-30 oil. Deposits were accumulated with each fuel and average rumble requirements were determined. Fuel A is a gasoline containing 3 ml tel per gal. Fuel B is a commercial gasoline containing approximately 3 ml tel per gal plus 0.22 theories of a phosphorus ignition control compound. Fuel C is a commercial gasoline containing neither tel nor phosphorus. Analytical data for the three test fuels are shown in Table 1. It is obvious that tel is a large contributor to the occurrence of rumble since the engine would not rumble on the lowest LIB fuel when deposits were accumulated with Fuel C. Fuel B containing a small amount of a phosphorus ignition control compound reduced the rumble requirement of the engine considerably compared to Fuel A which contained only tel. These data serve to illustrate the effects of tel and phosphorus even though the hydrocarbon composition of Fuel A is somewhat different from that of Fuels B and C.

Phosphorus Fuel Additives

From the preceding results it would appear desirable to eliminate tel from gasoline — if rumble were the only concern. From an antiknock standpoint, of course, tel is very effective and economical; therefore, its use will undoubtedly continue. However, as indicated in Fig. 5, phosphorus gasoline additives can be used to reduce rumble when leaded gasolines are used. The phosphorus combines with lead during combustion, forming lead-phosphorus compounds which are less likely to cause deposit ignition than the basic lead chlorides and bromides which are normally formed when leaded gasoline is burned in an engine. Because of this, use of phosphorus additives in gasoline appears to be a practical compromise; the antiknock advantages of tel can

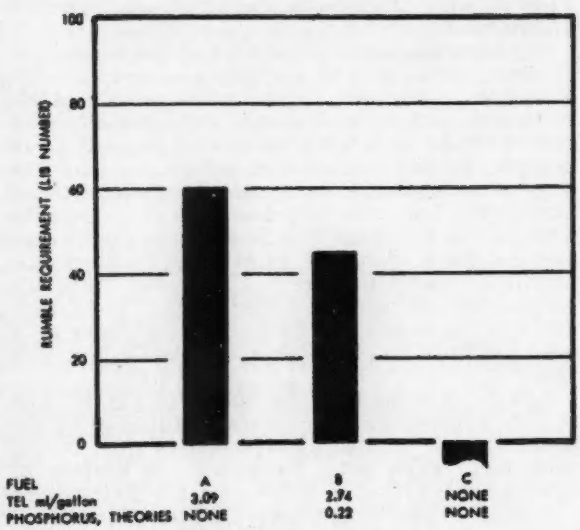


Fig. 5 — Variation in rumble requirements when deposits are accumulated with different types of fuel. 10:1 compression ratio; 3000 rpm; full throttle; engine dynamometer.

Table 1 — Fuel Analysis Data

	Fuel A	Fuel B	Fuel C
Specific gravity, 60 F	0.732	0.750	0.743
Tetraethyllead, ml per gal	3.09	2.74	nil
Reid vapor pressure, psi	4.8	12.0	12.3
Phosphorous, theories	nil	0.22	nil
Motor octane No.	100	88	87
Research octane No.	110	100	99
Distillation, F			
initial	117	84	85
10%	171	110	118
50%	214	207	214
90%	249	318	324
end	317	396	379
Hydrocarbon content			
Saturates, %	72	53	52
Olefins, %	10	16	16
Aromatics, %	18	31	32

Table 2 — Residual Benefits of Phosphorus

History of Phosphorus Usage		Stabilized Rumble Requirement with No Phosphorus (LIB Number)	Requirement Test Interval (Deposit Mileage)
Deposit Mileage	Phosphorus		
0–3700	None	100	1500–3700
(Combustion chamber deposits removed)			
0–6600	1 theory		
6600–9600	None	77	6900–9600
9600–17,800	½ theory		
17,800–22,500	¾ theory		
22,500–27,100	None	51	24,900–27,100

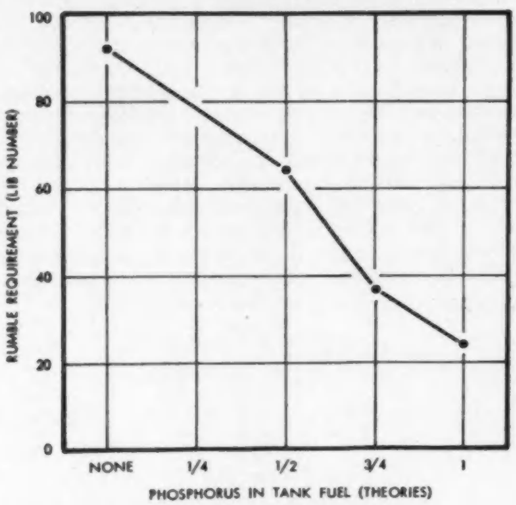


Fig. 6 — Reduction of rumble requirement when using various concentrations of phosphorus in the tank fuel. Average data from four cars; 12:1 compression ratio; full throttle accelerations.

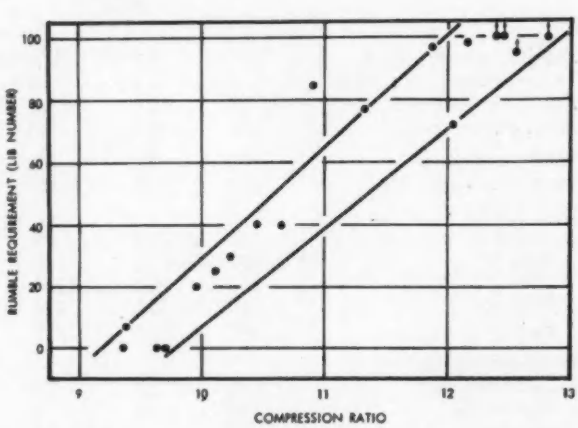


Fig. 7 — Rumble requirements of cars at various compression ratios. Full throttle accelerations.

be retained while at the same time deposit ignition and, hence, rumble can be minimized.

Nearly all of the phosphorus-containing gasolines marketed today contain between 0.1 and 0.3 theories of phosphorus. This amount of phosphorus appears to be reasonably effective at today's compression ratios but may not be adequate when higher compression ratios are reached. Because of this a deposit accumulation road test program was carried out to investigate the effectiveness of various concentrations of a phosphorus gasoline additive in reducing the rumble tendency of high compression cars.

The additive used during these tests was a commercial dimethylxylyl-phosphate compound. Tests were run at three different phosphorus concentrations; namely, ½ theory, ¾ theory, and 1 theory. The base fuel used during tests with each phosphorus concentration was a blend containing 75% alkylate, 15% toluene, and 10% diisobutylene, plus 3 ml tel per gal. This fuel is the same as Fuel A shown in Table 1.

Four 1958 test cars equipped with special 12:1 compression ratio V-8 engines were used during these tests. Cars of two makes were involved. Compression ratios of the engines were increased through the use of special pistons and cylinder heads obtained from the respective engine manufacturers. Combustion chamber deposits were accumulated under suburban-highway driving conditions with vehicle speed limited to 55 mph. LIB rumble requirements were determined at 200-mile intervals. These requirements were obtained during full-throttle accelerations from approximately 30 to 70 mph. A mid-continent fully distilled 20W oil was used.

The tests were arranged so that all concentrations of phosphorus were tested simultaneously in different cars during a given time period. After stabilized rumble requirements had been obtained, the test fuels containing various concentrations of phosphorus were switched to different cars. The tests were repeated until each concentration of phosphorus had been tested in each car. Deposits were accumulated for 3000 to 5000 miles with each fuel — until a stabilized rumble requirement was obtained. Deposits were not removed from the combustion chambers between tests. Tests were also run to determine the rumble requirement of each car when no phosphorus was used in the tank fuel.

Results of these tests are shown in Fig. 6. LIB rumble requirement is shown as a function of the concentration of phosphorus additive used in the tank fuel. Each point represents the average of requirements for all four test cars (10 observations per car). These data indicate that the use of phosphorus in the tank gasoline provides reductions in rumble requirement which are essentially proportional to the concentration of phosphorus used. It

appears that phosphorus additives in concentrations up to at least 1 theory can be used effectively to combat deposit ignition and rumble in high compression engines.

Further analysis of the data from these phosphorus tests indicates that the beneficial effects of phosphorus gasoline additives may be partially retained by the engine even though the use of phosphorus is discontinued. This is illustrated in Table 2 which includes three different values of stabilized rumble requirement for one of the test cars when using no phosphorus in the tank fuel. The three requirements are different because the history of phosphorus usage in the car was different prior to the period during which each of the requirements was determined.

The history of phosphorus usage in the tank fuel is shown in the first two columns. The stabilized rumble requirement and the mileage interval during which the requirements were determined are shown in the third and fourth columns, respectively, for periods when the car was operated with no phosphorus in the fuel.

From these results it can be observed that the use of phosphorus during portions of the mileage accumulation caused a residual benefit or reduction in rumble requirement during subsequent periods when no phosphorus was used. This residual benefit was more pronounced at high mileages.

An even more important point concerning the usage of phosphorus gasoline additives is that the effectiveness of a given concentration of phosphorus is reduced if phosphorus is not used continuously in the engine. The data shown in Table 3 illustrate this loss in effectiveness.

Stabilized rumble requirements are shown for two cars when using 1 theory of phosphorus in the gasoline. These two cars were of the same make and model and had essentially equal rumble requirements when no phosphorus was used. One car had previously used fuels containing none and ½ theory of phosphorus as shown in the Table. From these data it can be observed that the stabilized rumble requirement was considerably lower for the car which had used 1 theory of phosphorus continuously.

In summary, the foregoing data indicate that maximum rumble reduction with phosphorus gasoline additives can be attained only through continuous use. Intermittent use causes the phosphorus to be ony partially effective. Maximum effectiveness can, of course, be restored at any time by deposit removal and subsequent continuous use.

Deposit Ignition Resistance of Fuels

The inherent deposit ignition resistance of fuels may play an important part in the control of rumble in high compression engines. Fuels having high resistance to deposit ignition will minimize the occurrence of deposit ignition and rumble even in the presence of glowing deposits.

Measurements of the relative deposit ignition resistance of several fuels were made as long ago as 1954 in a single cylinder laboratory engine. These studies indicate that considerable difference exists between fuels. The work described here involves rating the deposit ignition resistance of several fuels in a car on the road.

Deposit ignition resistance ratings of each test

Table 3 — Loss of Effectiveness of Phosphorus Additive

History of Phosphorus Usage		Stabilized Rumble Requirement 1 theory of Phosphorus (LIB Number)	Requirement Test Interval (Deposit Mileage)
Deposit Mileage	Phosphorus		
0–6600	1 theory	4	4600–6600
0–6900	None		
6900–9600	½ theory		
9600–18,100	1 theory	48	15,900–18,100

Table 4 — Fuel Analysis Data for Deposit-Ignition-Resistance Tests

	Toluene	2,3 Dimethyl-butane	Gasoline D	Gasoline E
Specific gravity, 60 F	0.872	0.666	0.725	0.763
Tetraethyllead, ml per gal	1.0	1.0	2.90	2.91
Reid vapor pressure, psi	—	—	5.3	7.7
Phosphorus, theories	—	—	nil	nil
Motor octane No.	109	104	100	93
Research octane No.	>120	113	111	103
Distillation, F				
initial	Boiling Point	Boiling Point	120	96
10%			178	138
50%			208	224
90%	231	136	250	327
end			314	424
Hydrocarbon content				
Saturates, %	—	100	75	53
Olefins, %	—	—	9	9
Aromatics, %	100	—	16	38

Table 5 — Deposit Ignition Ratings

Fuel	Average Deposit Ignition Resistance Rating (LIB No.) Car	Single Cylinder
Toluene	46	42
2, 3-Dimethylbutane	73	86
Gasoline D	56	—
Gasoline E	55	—

Engine Rumble

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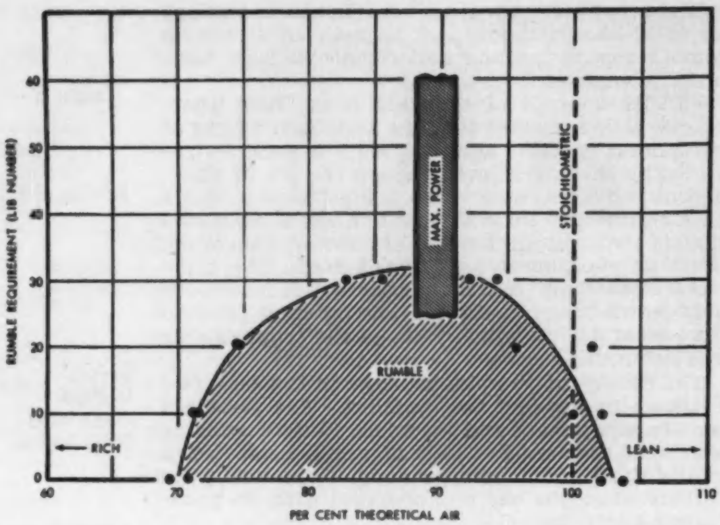

Fig. 8 — Effect of air-fuel mixtures on engine rumble requirement. 12:1 compression ratio, full throttle acceleration.

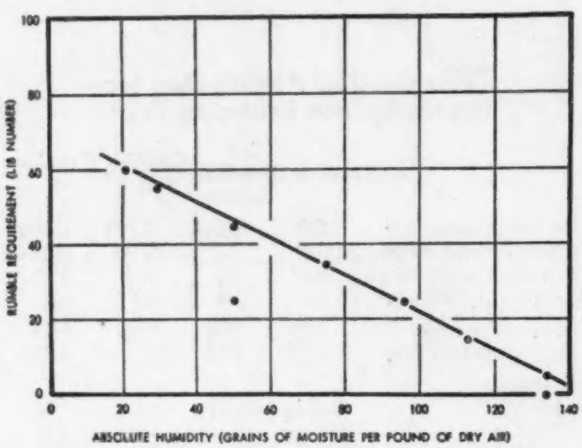

Fig. 9 — Engine rumble requirement as related to inlet air humidity. 10:1 compression ratio; 3000 rpm; full throttle; engine dynamometer.

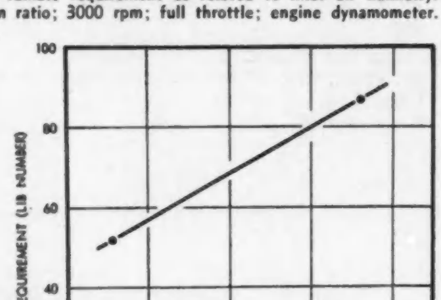

Fig. 10 — Influence of carburetor inlet air temperature on engine rumble requirement. 10:1 compression ratio; 3000 rpm; full throttle; engine dynamometer.

fuel were made by comparing its rumble resistance to that of various LIB reference fuel blends. This technique uses audible rumble as an indication of the presence of deposit ignition. The LIB rating of a given fuel is determined by: 1. observing the intake manifold vacuum that produces trace rumble during an acceleration when using the test fuel; and 2. determining the LIB blend that also produces trace rumble at the same manifold vacuum. The LIB number of the matching blend represents the deposit ignition rating of the test fuel — the higher the rating, the greater the deposit ignition resistance of the fuel.

Four fuels were rated in a 1958 test car equipped with 12:1 compression ratio cylinder heads. Analytical data for the fuels are shown in Table 4. Deposit ignition ratings are shown in Table 5. Each rating is the average of 10 daily ratings. Only one fuel was rated each day with approximately 200 miles of deposit accumulation between tests. Laboratory single cylinder engine ratings are also shown for toluene, and 2, 3-dimethylbutane. Single cylinder ratings were made at full throttle using a deposit injection technique.

The important conclusion from these data is that this technique can be used to separate fuels with respect to deposit ignition or rumble resistance in a car on the road. Agreement beween road and laboratory ratings is fairly good.

Having established a workable technique, six commercial super-premium grade gasolines were obtained and rated for deposit ignition resistance. Analytical data for these gasolines are included in Table 6. The test car was a 1959 model equipped with a V-8 engine modified to 12.5:1 compression ratio. Fuels were rated in the same manner as described previously. Fuel ratings are presented in Table 7. Each value shown is the average of six daily ratings. The average ratings of the six gasolines are not significantly different in spite of fairly wide differences in hydrocarbon composition. It is interesting to note that Gasoline E was rated at 57 LIB numbers in these tests compared to 55 LIB numbers in the previous tests.

Table 6 — Fuel Analysis Data for Deposit-Ignition-Resistance Tests

	Commercial Gasolines					
	Brand E	Brand F	Brand G	Brand H	Brand I	Brand J
Specific gravity, 60 F	0.763	0.728	0.731	0.734	0.730	0.708
Tetraethyllead, ml per gal	2.91	2.40	2.56	2.84	2.44	2.25
Reid vapor pressure, psi	7.7	11.2	12.0	11.9	11.3	12.7
Phosphorus, theories	nil	0.29	0.26	0.25	0.43	0.20
Motor octane No.	93	92	92	90	92	96
Research octane No.	103	102	101	101	101	102
Distillation, F						
initial	96	82	84	84	88	87
10%	138	121	115	117	126	108
50%	224	210	221	203	224	203
90%	327	316	350	288	322	311
end	424	398	424	378	394	384
Hydrocarbon content						
Saturates, %	53	67	68	54	63	80
Olefins, %	9	9	11	17	15	7
Aromatics, %	38	24	21	29	22	13

The ratings of these six fuels indicate that there may be very little difference among the deposit ignition resistances of present-day commercial gasolines.

Since none of the six gasolines tested have high resistance to deposit ignition, it appears that a fertile area for further research is the development of gasolines having high deposit ignition resistance. Single cylinder engine studies indicate that fuels can be formulated which will have this quality.

Engine Operating Variables

Engine rumble, as the name implies, is not a phenomenon that can be entirely divorced from engine design. It has been observed, however, that changes in the structural design of the engine within practical limits has little effect on the occurrence of rumble. Even though the resonant frequency of the engine parts may be altered, rumble will still occur whenever the rate of cylinder pressure rise or peak cylinder pressures are excessive. In other words, structural design changes may alter the characteristics of the rumble noise, but cannot cure the basic problem — abnormal combustion.

Certain other engine design and operating variables do have an effect on rumble through their influence on the combustion process. These include compression ratio, air-fuel mixture ratio, inlet air humidity and temperature, engine load, and engine speed.

Compression Ratio

The influence of compression ratio on the occurrence of rumble is shown in Figure 7. Rumble requirements of several 1958, 1959, and modified high compression cars are shown as a function of measured compression ratio. The cars had accumulated from 1,741 to 30,786 miles in company transportation service. All cars were using commercial 20W motor oils but were operated with a variety of fuels.

Production cars were operated on commercial premium grade gasolines and the high compression cars were operated on special high octane, nonphosphorus fuels. Rumble requirements were determined during full throttle accelerations from approximately 1000 to 4000 engine rpm.

With one exception the requirements fell within a fairly narrow band. The cause for this unusually high requirement was not apparent. In general, the data indicate that rumble requirement increases at the rate of approximately 35 LIB numbers per compression ratio.

Air-Fuel Ratio

Rumble is most likely to occur at or near maximum power air-fuel ratio. This conclusion was

Table 7 — Deposit Ignition Ratings for Commercial Gasolines

Super-Premium Gasoline	Average Deposit Ignition Resistance Ratings (LIB No.)
Brand E	57
Brand F	57
Brand G	62
Brand H	57
Brand I	56
Brand J	61

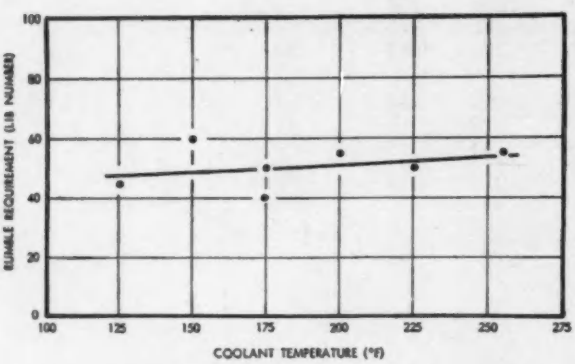

Fig. 11 — Relationship between coolant temperature and rumble requirement. 10:1 compression ratio; 3000 rpm; full throttle; engine dynamometer.

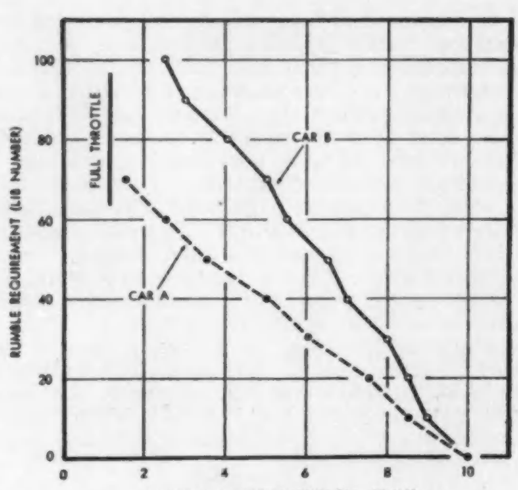

Fig. 12 — Reduction in rumble requirement as intake manifold vacuum is increased. 12.5:1 compression ratio; accelerating conditions.

drawn from test results obtained using a 12:1 compression ratio car equipped with a fuel injection unit. Fuel injection was used for two reasons: 1. it provided uniform mixture distribution, and 2. it permitted changes in mixture ratio to be made conveniently.

Rumble requirements were determined at various mixture ratios during accelerations at wide-open throttle in third gear from 1500 to 4200 rpm. The results are shown in Figure 8. LIB number requirements are shown as a function of per cent theoretical air in the mixture. Per cent theoretical air was used to express air-fuel mixtures because the individual LIB blends have different hydrogen-carbon ratios. Rumble requirement is maximum at about 88–90% theoretical air. This corresponds to maximum power for this engine as shown in Fig. 8. A mixture of 88–90% theoretical air is equivalent to an air-fuel ratio of about 13:1 when using commercial gasoline.

Inlet Air Humidity

Humidity has a pronounced effect on the occurrence of rumble. The relationship between humidity and engine rumble requirement was studied using dynamometer equipment. As shown in Fig. 9, rumble requirement decreased from 60 to 5 LIB numbers as absolute humidity was increased from 21 to 134 grains of moisture per lb of dry air. This variation in humidity represents the range normally encountered during a year in the Midwest. During the tests, carburetor inlet air temperature and coolant temperature were held constant. Humidity was controlled during test observations only. These data demonstrate that humidity has a large influence on engine rumble requirement.

Inlet Air Temperature

Inlet air temperature was also found to have an effect on the occurrence of rumble. Tests were run on the engine dynamometer under constant absolute humidity and coolant temperature conditions. As shown in Fig. 10, a 60 F increase in carburetor inlet air temperature increased the engine rumble requirement by 35 LIB numbers. It should be pointed out that the effect of inlet air temperature and humidity tend to cancel each other during seasonal weather variations since humidity generally increases with ambient temperature.

Coolant Temperature

Engine coolant temperature was found to have very little effect on rumble. A range of coolant temperatures from 125 to 255 F was investigated using an engine dynamometer. Constant values of inlet air temperature and humidity were maintained.

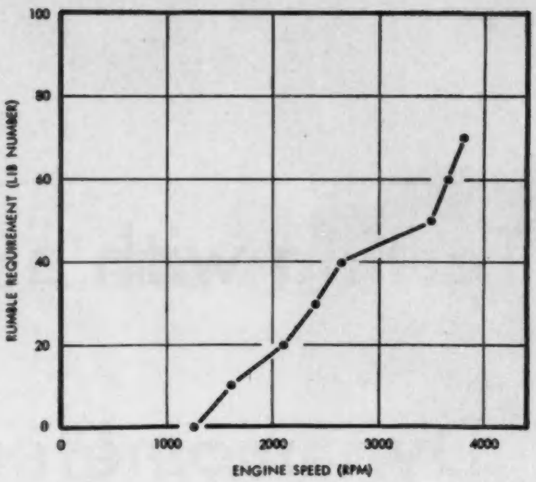

Fig. 13 — Increase in rumble requirement with increased engine speed. 12:1 compression ratio; full throttle acceleration.

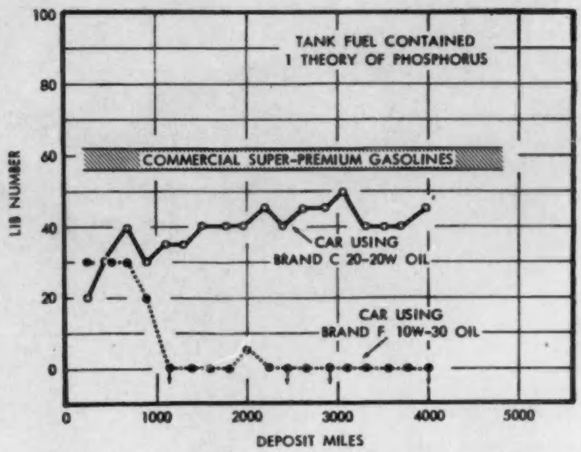

Fig. 14 — Rumble requirements of 12:1 compression ratio cars operated under city traffic conditions (full throttle accelerations).

The results are shown in Fig. 11. It can be seen from the data that changes in coolant temperature produced no significant change in engine rumble requirement.

This result was not anticipated since previous road test experience had indicated an increase in rumble requirement when coolant temperature was increased. However, it must be remembered that the inlet air temperature in a car is partially dependent on the coolant temperature; therefore, when coolant temperature is increased, any corresponding increase in inlet air temperature may result in a higher rumble requirement.

Engine Load

The occurrence of rumble is more pronounced at high engine loads. The LIB rumble requirements of two 12.5:1 compression ratio cars of different make were obtained at various engine loads. These data are shown in Fig. 12. Engine load is expressed in terms of intake manifold vacuum which is an inverse function of engine load. Rumble requirements were determined during constant manifold vacuum accelerations. The requirements for both cars were progressively reduced as intake manifold vacuum was increased. This characteristic of rumble occurrence was utilized to vary engine rumble severity during the deposit-ignition-resistance ratings of fuels described earlier.

Engine Speed

Rumble occurs more frequently at high engine speeds. The effect of speed on rumble requirement was determined during full-throttle accelerations with a 12:1 compression ratio car. The results are shown in Fig. 13. It is evident that engine rumble requirement increases rapidly as engine speed is increased.

12:1 compression ratio with proper fuels and lubricants

Many of the factors which affect the occurrence of engine rumble have been discussed in the preceding sections. One question remains, however, and that is: Can a high compression engine be operated without rumble when deposits are accumulated under light-duty city traffic conditions?

To answer this question, two identical cars equipped with 12:1 compression ratio V-8 engines were operated under simulated city traffic conditions. Combustion chamber deposits were removed before the tests. The cars were driven very moderately with top speed limited to 35 mph. Average speed was 15 mph with an average of 3.6 stops per mile. Rumble requirements were determined at 200-mile intervals over a period of 4000 miles.

One test car was operated with a "good" oil (Brand F, 10W-30) and the second car was operated with a "mediocre" oil (Brand C, 20W). Both cars used a "good" fuel (Fuel A containing 1 theory of dimethylxylyl phosphate).

Rumble requirements for both test cars are shown in Fig. 14. The requirement stabilized at essentially zero LIB for the car using the 10W-30 oil and at 40 to 50 LIB for the car using the 20W oil. Superimposed on the figure is a band including the average LIB rumble ratings of the six commercial super-premium gasolines shown in Table 7. This band provides an indication of the rumble resistance of commercial-type gasolines for comparison with the car requirements. The rumble resistance of the commercial gasolines is higher than the requirements of both test cars. This demonstrates that these 12:1 compression ratio cars can be operated satisfactorily with respect to rumble under city traffic conditions if fuels and oils are properly selected.

To Order Paper No. 83U
... on which this article is based, turn to page 6.

Road Testing with an Dynamometer

Based on paper by

O. G. Lewis
R. R. Risher, Jr.
and
J. A. Wilson

Esso Research and Engineering Co.

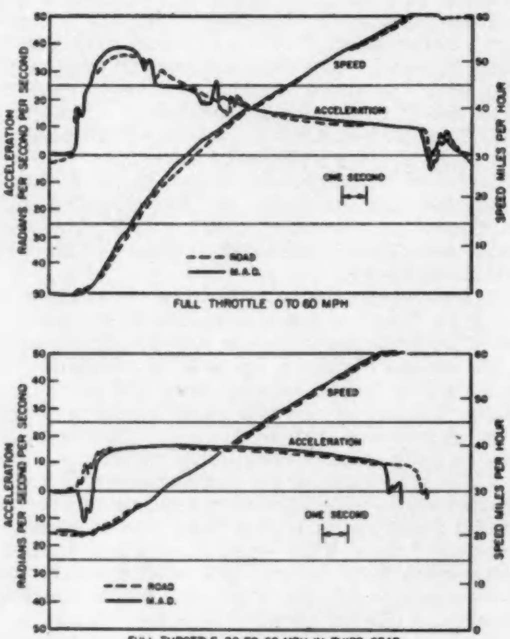

Fig. 2 — Speed and acceleration curves show close correlation between mileage accumulation unit and road results.

TO ADVANCE fuels and lubricants research, Esso has developed an eight-lane dynamometer facility, which permits test car mileage to be accumulated at one-sixth the cost incurred on the road, eliminates the variables of test drivers' driving habits, enables high-speed work to be done safely, and reproduces road loads under accelerating conditions adequate for road octane rating work.

A cutaway view of the multi-unit dynamometer installation is shown in Fig. 1. The dynamometer system consists of a pair of traction rolls belted to a variable weight inertia disc shaft. This, in turn, is belted to a large squirrel cage blower selected to reproduce the nonlinear wind loading required and to direct an air stream at road speed at the front of the vehicle for engine cooling. The volume of air can be varied by remote control to alter road load conditions or vehicle underhood temperatures. The chain drive to the high-pressure hydraulic pump is coupled to the intermediate inertia disc shaft.

Since the hydraulic pump/motor system is limited to a top speed of 85-mph road speed, two units in the multiple installation are equipped with high-capacity friction disc brakes. These units permit safe test car operation up to 125 mph. They can accommodate Borderline-type octane rating and supply sufficient braking force to stall even the highest powered car.

New device for car holddown

A hydraulically controlled car holddown and rear wheel positioning device was designed to eliminate vertical tie-down forces by holding the positioner in tension and parallel to the ground at the test vehicle wheel centerline. This device simplifies test car positioning, eliminates potentially dangerous front wheel chocks and the vertical tie-down loading component imparted to the rear tires by chains attached to a vehicle's bumpers or frame.

No modifications or alterations to the test vehicle are required to install it on the dynamometer. Alli-

8-Lane Highway

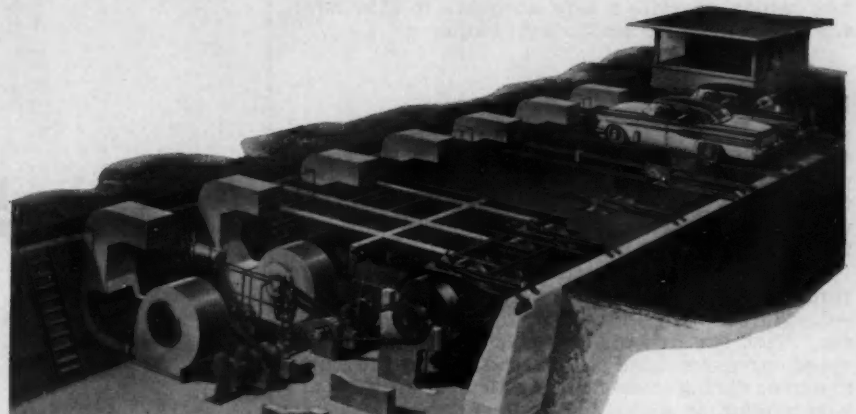

Fig. 1 — Cutaway view of Esso 8-lane mileage accumulation dynamometer.

gator clips are used to make all necessary electrical connections to the vehicle.

Magnetic tape programming

Three tape playback controllers provide simultaneous, automatic test car control under any three desired operating conditions — the mileage accumulation test course, sustained high-speed turnpike driving, continuous city driving, or any other prerecorded driving condition. All or any one of the test cars can be operated from any one of the tape controllers by switch selection at the control console. The controllers, working through a closed-loop servo system, move a clamp attached to the test car acceleration pedal in exact reproduction of the foot movements of the original "average" driver.

The master control tapes also contain vehicle braking control signals. On playback, these signals activate the dynamometer hydraulic braking sys-

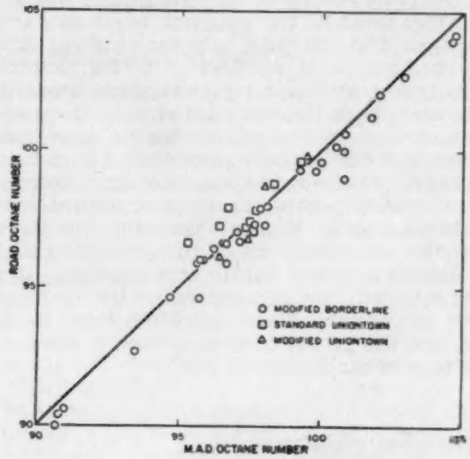

Fig. 3 — Road octane ratings made on dynamometers agree well with on-the-road ratings. Dynamometer installation saves time and money in rating.

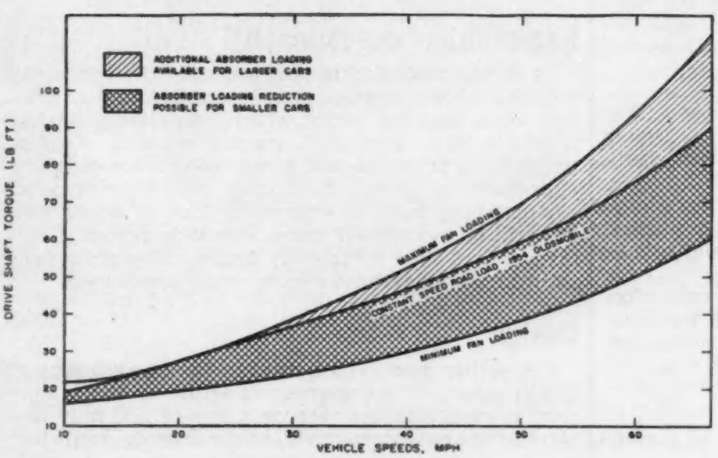

Fig. 4 — Torque absorbing capacities of blowers from 10 to 60 mph bracket the actual test car constant-speed road load torque curve very well.

tem, which provides a load adequate to slow down the test vehicle for traffic light stops.

Installation evaluation

Test cars operating on the dyamometers over the tape-programmed 3-hr and 26-min cycle of city, suburban, and highway driving and containing 187 traffic stops, travel from 103 to 106 miles. The survey vehicle, which recorded the control tape, actually travelled 104 miles.

A test car full-throttle acceleration from a standing start to 60 mph on the road requires 13.8 sec. The same car on the dynamometer requires 13.7 sec. Test car driveshaft acceleration and vehicle speed curves recorded on the road and on the dynamometer during these full throttle accelerations are very similar, as shown in Fig. 2.

Octane evaluations of some 45 test fuels rated by the modified Borderline, Uniontown, and Modified Uniontown rating procedures were obtained from both road and dynamometer. The correlation is shown in Fig. 3. The equation of the regression line is not significantly different statistically from a perfect (1/1) correlation.

Road speeds under mileage accumulation driving are continuously changing and the inertia disc system provides most of the loadings required during accelerations and coasting. Under constant-speed driving, road loading is provided by the fan absorber, as shown in Fig. 4. The torque absorbing capacities of the blowers from 10 to 60 mph bracket the actual test car constant-speed road load torque curve fairly well. The test car constant-speed road load below 20 mph slightly exceeds the fan capacity. However, this is not critical because nearly all constant-speed driving is in excess of 20 mph. Moreover, the inertia discs provide essentially all of the low-speed high-torque loading required during accelerations. Road loads for different test cars can be set by the proper selection of inertia discs corresponding to car weights, and the proper control of blower vanes according to test car frontal areas.

Some outstanding advantages

Test car mileage accumulation on the dynamometer costs about one-sixth as much as road accumulation. At an average speed of 25 mph, eight cars can be driven:

4800 miles/24 hr.
3600 miles/24 hr with normal 0.7 use factor.
1,200,000 miles/year with 0.7 use factor.

Other attractive features are:

- Elimination of the variable of test drivers' driving habits.
- More test fleet and engine technician flexibility.
- Elimination of driver work scheduling problems.
- Expansion of research activities without a corresponding increase in the technical staff.
- Octane rating cost is reduced, while reduction in octane rating time losses permits more frequent ORI ratings and increases test car octane rating capacity in general.

To Order Paper No. 69U ...
... on which this article is based, turn to page 6.

Many Elements

Based on report by secretary

Gordon S. Mead

North American Aviation, Inc.

IMPROVEMENT of a product reliability program requires careful and constant analysis of every element of the entire industrial process:

1. Organization.
2. Research and Development.
3. Design.
4. Qualification testing.
5. Manufacturing.
6. Quality control
7. Packaging and shipping.
8. Field Service.

Organization

A weapons system contractor, an equipment manufacturer, and a component manufacturer are faced with radically different problems in the overall philosophy of organization, as well as in the specific problem of organization for reliability. Reliability, in all cases, however, should reflect an important position in the management effort. This effort should provide not only for the establishment of a reliability policy but also for the complete implementation of the established policy.

Research and development

In the aircraft and missile industry the terms *research* and *development* may be applied to that portion of a feasible study which establishes design concepts to accomplish a specific mission. Design parameters to accomplish the mission ultimately are expressed as design specifications. The finished product may meet the specifications in every way but will be completely unreliable if any fact of the mission has been incorrectly stated. The manufacturer must understand clearly what is required.

Design

Reliability must be inherent in the basic design of the product. The designing function of the industrial process has the responsibility of not only designing the equipment to meet the specifications but

Fix Product Reliability

to accomplish it with techniques which will provide a reliable product.

Design practices which are recommended for imparting reliability to the product are:

1. Simplicity of design.
2. Realistic tolerances that can be accomplished in production.
3. Proper selection of components and materials.
4. Application of fail-safe techniques in critical areas of operation.
5. Proper consideration of new techniques, and their reliability as estimated from similar experiences.
6. Ease of maintenance.

Qualification testing

There is a need, of course, to fully qualify all systems, subsystems, equipment, and components before production in quantity is undertaken. Many companies test until failure is induced. This tells you how far you can go and what the design safety factor is.

Today, the number of similar parts being produced for a given missile or airframe is relatively small. There isn't available, as there is in the consumer industries, a universe of sampling and testing for greater understanding of reliability probabilities. By all means have a statistician help design your testing system and qualification procedures. And, be sure you get the most information possible from the high cost items that must be fully tested.

Manufacturing

In the manufacturing area, production consistency is one of the major factors which must be attained. The manufacturing cycle must be controlled so that any variance can be evaluated as to the effect it has on product reliability. (The production of parts on numerically controlled machines is an example of an effort to produce a consistent part.)

Quality control

Quality control has generally been a "policing" function to ascertain if manufacturing is producing parts and products in accordance with engineering specifications. The collection of detailed statistical data to cover rejects and failures can assist the entire organization if the information is properly interpreted and disseminated. A complete history of components which have a high unreliability factor should be maintained.

Packaging and shipping

For improvement of the reliability program, every element of the entire industrial process requires careful and constant analysis. The packaging and shipping function is highlighted to emphasize the importance of getting the product to the user as manufactured and in a condition capable of accomplishing the mission for which it has been designed.

Field service

Each function of the organization must be dedicated to a policy whereby present products must be substantial improvements of all previous models. Furthermore, the product of tomorrow must surpass all existing standards for quality of design and performance. The field service function must provide this performance data in a language that can be easily understood by the product designers, process engineers, manufacturing executives, and quality control managers. With this information, corrective measures can then be installed in the industrial process to achieve an improved product.

Serving on the panel which developed the information in this article, in addition to the panel secretary, were: **Glenn W. Periman**, North American Aviation, Inc.; **George B. Foster**, Industrial Nucleonics Corp.; **Ernie A. Wright**, North American Aviation, Inc.; **Stanley B. Sherwood**, General Motors Corp.; **William Stieglitz**, Republic Aviation Corp.; **Erwin A. Zeiser**, Fairchild Engine & Airplane Corp.; **Col. Robert Mitterling**, USAF, AMC; and **Kenneth Warner**, North American Aviation, Inc.

(This article is based on a secretary's report of a production panel entitled "Product Reliability." This report — along with 6 other secretaries' reports on various aircraft production subjects — is available in multilith form as SP-327. See order blank on p. 6.)

Better thermocouple alloys make 1800 C measurement feasible

Based on paper by

R. C. Lever

General Electric Co.

AS modern technologies continue to advance, the need for measuring higher temperatures with accuracy and reliability becomes more severe. It appears that improved high-temperature thermoelectric alloys having a better combination of properties can be developed. The ultimate temperature-measurement capacity of alloys operating unprotected in an oxidizing atmosphere should be about 1800 C and consist of platinum metals containing minor alloying additions.

Table 1

Metallic Elements Melting Above 1400 C

Material	Melting Point, C	Material	Melting Point, C
Tungsten	3400	Thorium	1842
Rhenium	3167	Zirconium	1830
Tantalum	2996	Platinum	1773
Osmium	2700	Titanium	1690
Molybdenum	2622	Palladium	1554
Iridium	2454	Chromium	1550
Columbium	2415	Iron	1540
Ruthenium	2400	Cobalt	1493
Hafnium	2130	Nickel	1455
Boron	2100	Yttrium	1425
Rhodium	1966	Silicon	1410
Vanadium	1900		

Temperature-measuring systems based upon the thermocouple continue to be used because of their simplicity and other desirable features. Some of these features are:

1. Thermoelectric output yields a relatively direct indication of the quantity to be measured; that is, it is essentially unaffected by the presence of fumes, varying emissivities, or other variables often requiring correction by other systems.
2. The small mass of hot junctions gives rapid response to temperature changes.
3. The low impedance of thermoelements makes it easier to obtain adequate electrical insulation at high temperatures than in, for example, systems employing thermistors.
4. Thermocouple systems can be made small, lightweight, and rugged — they can be formed into complex shapes, readily assembled and maintained, and have the simplicity to permit multiple circuitry to protect against electrical failures.

Despite these advantages, as technologies advance, much improvement in thermocouple systems will be needed if they to continue to play their predominate role.

The ideal thermoelectric combination of materials would have:

1. Melting points far higher than the temperature to be measured to preserve the stability of the thermocouple.
2. Output high enough to obtain high accuracy; the output must be primarily linear with temperature, without maxima, minima, or sudden bends.
3. High chemical and metallurgical stability within the environment of intended operation so as to maintain consistency of calibration and reproducibility. Also, the material must remain homogeneous to avoid spurious voltages being created by temperature gradients.
4. Reproducibility of materials in fabrication, and in service, adequate physical properties to withstand thermal shock, vibration, and such.

Each of these items can be discussed in detail un-

der the headings of: Ultimate Temperature Limitations, Chemical and Metallurgical Stability, and Thermoelectric Output.

Ultimate temperature limitations

One of the most definable properties of a material is perhaps its melting point. It, of course, determines the ultimate operating temperature limit. Fig. 1 compares the melting temperatures of several types of materials which might be used as thermoelements. Note the relatively high melting points offered by metallic elements. Metallic elements further command attention because their properties regarding thermal shock, vibration, high-temperature strength, and fabrication are generally favorable and much is known about them. Table 1 lists metallic elements having melting temperatures above 1400 C.

Materials included in Table 1, and others, have been considered as comprising three broad categories. These are: base metals, refractory metals, and noble metals. Although considerable overlap exists between categories, a general distinction, on the basis of two important properties, melting point, and resistance to oxidation, can be made.

Base materials, which include iron, nickel, chromium, aluminum, copper, and such, are characterized by relatively low melting points and moderate resistance to oxidation at elevated temperatures. The refractory elements: molybdenum, tungsten, vanadium, titanium, zirconium, columbium, and such, have melting points which include the highest, but unfortunately also exhibit the least resistance to destructive oxidation. The noble metals, consisting of the six platinum metals, ruthenium, rhodium, palladium, osmium, iridium, platinum, and two lower melting point elements — gold and silver, take a more or less intermediate position with melting points ranging from slightly above the base metals to those comparable with refractory elements. The noble metals, in general, possess the most superior resistance to destructive oxidation.

Considering melting points and oxidation resistance alone, it would appear conceivable to measure temperatures in the vicinity of 3000 C with tungsten-based alloys, if it were possible to adequately protect them from oxidation; and temperatures up to 2000 C with noble metal-base alloys in oxidizing atmospheres.

Chemical and metallurgical stability

Refractory metal alloys might overcome the two limitations of thermocouples, namely, low maximum measurable temperature and low millivolt output, if they did not also exhibit rapid deterioration by oxidation at elevated temperatures. The desirability of employing thermoelements not requiring protection is fundamental in many instances of high-temperature measurement when time-response is an important consideration. For instance, in jet aircraft, the purpose of high-temperature measurement is to obtain an indication of engine performance in terms of thrust and prevent over-temperature from occurring within such vital parts as turbine bucket-blades. In performing the first function, a time constant of 5–10 sec may not be objectionable and may even be desirable to obtain some smoothing of data. But, in performing the

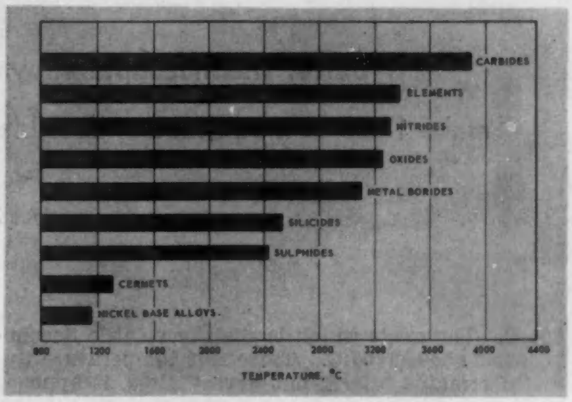

Fig. 1 — Approximate melting points of material types.

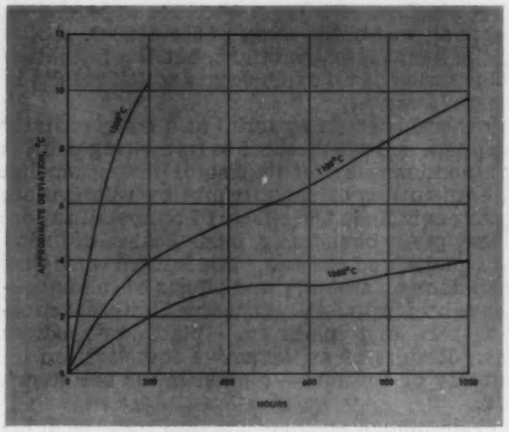

Fig. 2 — Stability of chromel-alumel in air.

second function of providing over-temperature protection to vital parts, it is desirable that the time constant be as small as possible. The additional mass of hot junctions contributed by protective coatings, sheathings, and such, as needed by refractory metals, makes the short-time constants more difficult or impossible to attain.

The elements in Table 1 which possess some resistance to oxidation are the four platinum metals: palladium, platinum, rhodium, and iridium. The other two platinum metals, ruthenium and osmium, lose weight too rapidly at elevated temperatures to consider them for more than minor alloying additions. The limited oxidation which takes place with the four platinum metals may result in the formation of volatile oxides effecting a change in composition either by the primary loss of a constituent directly, or by deposition of the constituent on the neighboring leg of the thermocouple.

That loss in weight of platinum is associated with oxide volatization has been proved by showing that the loss upon heating platinum in air decreased with decreasing pressure, that the loss was very small in nitrogen, and that no discernible loss occurred in hydrogen.

Rhodium oxidizes slowly on heating in air at about

Better thermocouple alloys make 1800 C measurement feasible

. . . continued

600 C. The oxide which is slightly volatile decomposes at about 1000 C. Above this temperature the metal remains bright, but nevertheless, it appears that oxygen increases the rate of volatization in the higher temperature region. Palladium is superficially oxidized when heated to about 700 C. The oxide decomposes above 875 C resulting in a bright metal. Oxidation of iridium becomes apparent on heating in air within the range of 600–1000 C. Above 1000 C the metal remains bright, but the formation and volatization of an oxide occurs which results in fairly high losses.

Every thermoelectric material at a comparatively high temperature with respect to its melting point is subject to influences contributing to inhomogeneity. In addition to loss of constituents by volatization, other factors include the effects of recrystallization, grain size, grain boundaries, oxide scales, diffusion of constituents, and stresses. The limited work that has been done on stability and effects of inhomogeneity have been principally concerned with the chromel — alumel and platinum — platinum-rhodium systems. Results of an extensive investigation on the stability of chromel — alumel in air are shown in Fig. 2.

The evaluation of mechanisms that cause such instability is difficult. In one set of experiments, a simple apparatus was used in which either chromel or alumel wires were clamped to silver binding posts mounted 36 in. apart on a panel. A pair of extension wires connected the ends of the test wire to the input of a photoelectric recorder, used as a 100-0-100 microvoltmeter. A miniature heater, made by winding a 2 in. long ceramic tube with nichrome wire over 1 in. of its length produced 800–900 C at its center. A clamping band on the heater was fastened to an endless cable, driving the heater along the wire at approximately 1 in. per min.

The wire on each side of the hot point was regarded as half of a thermocouple, so that in effect, if the wire were homogeneous over its length, the voltage output observed would be expected to remain constant, independent of heater position. Fig. 3 shows typical results obtained in testing chromel and alumel wires this way in the as-received condition and after annealing in nitrogen at 950 C for $1\frac{1}{2}$ hr. The differences obtained after annealing are attributed principally to relief of stresses caused in coiling and straightening the wires. The remaining deviations are attributed to inhomogeneities not eliminated by the simple annealing treatment given.

In similar experiments, involving the effect of stress, sample wires were bent to various predetermined angles varying from 5 deg to 90 deg and then straightened, resulting in different degrees of cold work. A deflection was indicated on the photoelectric recorder at the site of each bend resembling an alternating cycle, the amplitudes increasing with increasing angle of bend. Peak-to-peak amplitude for specimens bent to 90 deg were found to be about 35 mv for alumel and 55 mv for chromel. Similar indications were obtained when localized areas of oxide scale were removed.

It has been indicated that grain growth is a factor affecting the life of platinum thermocouples. Grain growth may proceed to an extent that single grains occupy the entire cross-section of wire. Apparently grain size, per se, has little effect, but the width of grain boundaries do. It is assumed that contamination is more rapid in the areas of broad grain boundaries.

It also has been noticed that the temperature range of 400–600 C rhodium oxide forming on the platinum-rhodium leg of a thermocouple may effect

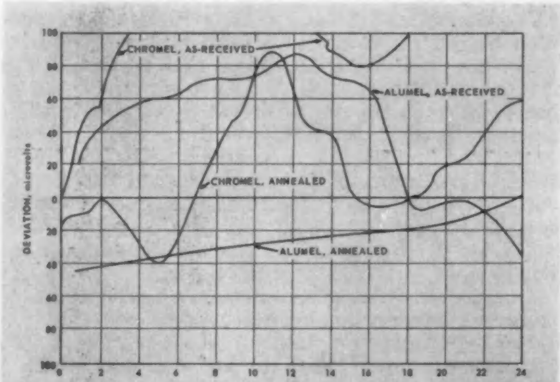

Fig. 3 — Microvolt deviation along lengths of chromel-alumel.

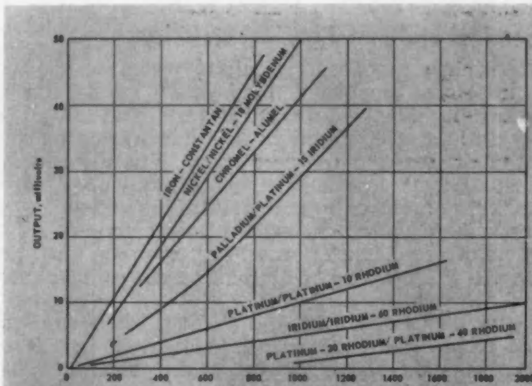

Fig. 4 — Relative outputs of base, noble, and refractory thermoelements.

a composition change sufficient for a change in calibration to be evident. However, a platinum-platinum-13% rhodium couple after having been in service more than 3 yr at 1290 C, and having an oxidized portion on the platinum-rhodium leg about 12 in. long, indicated a change equivalent to only 6–9 C.

The sources of inhomogeneity contributing to instability therefore, thus far, have been found to be relatively small and the basic causes which generate instability, particularly as found in base metals, remains unclear.

Thermoelectric Output

A large thermoelectric output signal is desirable to obtain high accuracy and permit simplicity in amplifying and indicating instrumentation. The platinum metals offer high-temperature measurement potential and stability of output, but they have comparatively low outputs. Fig. 4 shows the comparative outputs of a number of materials with temperature.

Little has been done on improving the output of noble metal combinations by selective alloying. Theoretical and empirical treatments of the thermoelectric behavior of base and noble metals indicate, however, that this may be possible.

The thermoelectric power of a metal is attributed to how current carriers within the metal are scattered by thermal vibrations, foreign atoms, vacancies, dislocations, and such. Several investigators have derived expressions for the absolute thermoelectric power of metals and dilute alloys. Also, several empirical rules have been proposed.

One rule states that alloying small amounts of metals preceding aluminum in the column-of-eight periodic table causes the absolute thermopower of aluminum to be less negative, and adding small amounts of metals following aluminum, causes its absolute thermopower to be more negative.

Another rule states that if two noble metal thermoelements make up a thermocouple, the one having the greatest impurity resistivity will be less thermoelectrically positive This is because the noble metals (Cu, Ag, Au) have positive absolute thermopowers. On the other hand, the reverse polarity occurs if the solvent metal is one of the alkali metals which have a negative absolute thermopower. Known exceptions to this rule are manganese, chromium, and titanium dissolved in copper. In general, the initial slopes of thermopower versus composition curves increase with increasing valence for various elements dissolved in copper.

While such rules are by no means exact, it is interesting to note that nickel is used as the base material for both positive and negative legs in the chromel-alumel system with the thermoelectric properties being controlled by alloying additions. Fig. 5 shows that unalloyed nickel is thermoelectrically negative with reference to platinum as a standard. The addition of approximately 10% by weight of chromium (positive with respect to platinum) to nickel results in the highly thermoelectrically positive alloy, Chromel-P. On the other hand, additions to nickel of approximately 1% silicon (negative), 2% aluminum (positive) and 2% manganese (positive) produces the thermoelectrically negative leg, alumel. Also, when 45% of copper (highly positive) is alloyed

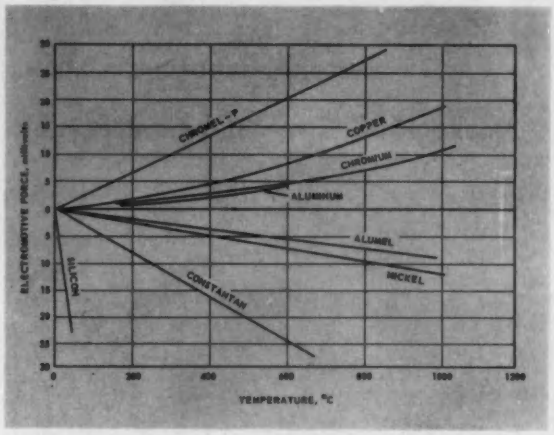

Fig. 5 — Thermoelectric outputs of elements and their alloys.

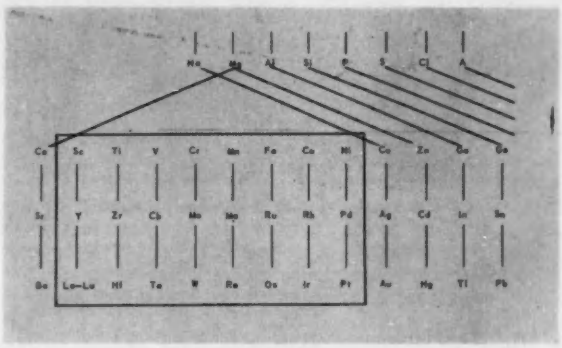

Fig. 6 — Portion of periodic table.

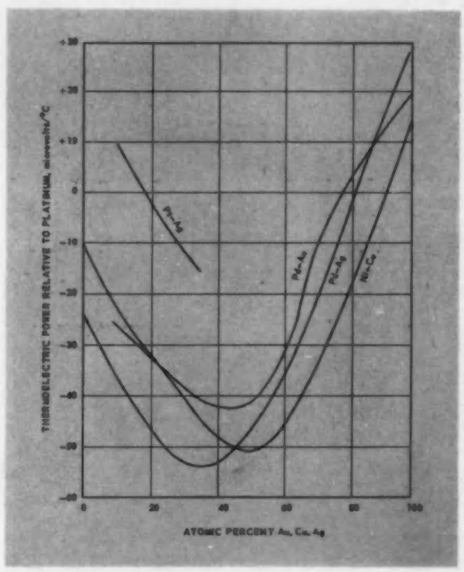

Fig. 7 — Effects of alloying group VIIIa and group Ib elements.

Better thermocouple alloys make 1800 C measurement feasible

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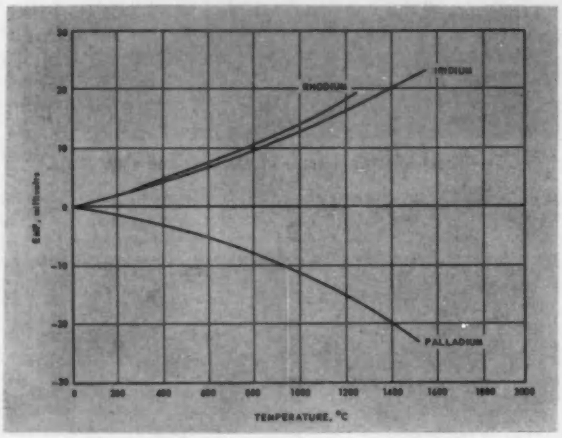

Fig. 8 — Relative outputs of platinum elements.

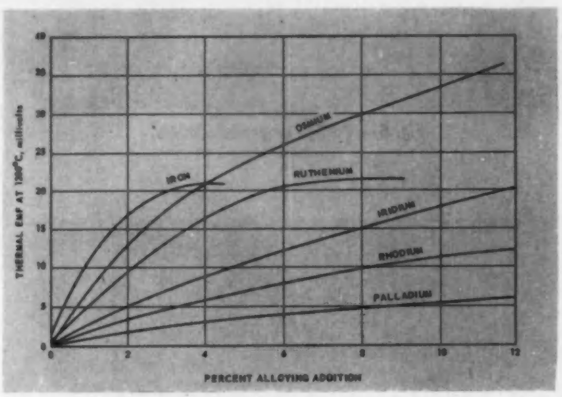

Fig. 9 — Effect of alloying additions to platinum.

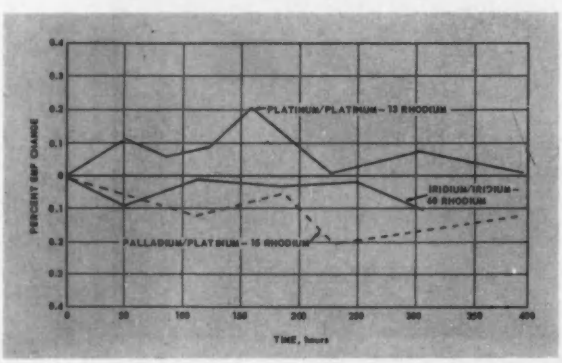

Fig. 10 — Results of stability testing palladium-platinum-15% rhodium.

with nickel, it produces one of the most negative alloys, constantan. From these examples, there does not appear a pattern between whether the additions are thermoelectrically positive or negative and the sign of the output obtained from the alloy. However, if the positions of the alloying elements in the periodic table are examined a pattern becomes evident.

Fig. 6 shows the portion of the periodic table which is of interest. The element chromium appears to the left of nickel, resulting in the positive alloy chromel. The elements, aluminum and silicon, appearing to the right of nickel causes the alloy alumel to be negative. Also the element copper, again appearing to the right of nickel, results in making constantan thermoelectrically negative.

There are, of course, exceptions to this simple relationship, but an additional fact occurs which is of some interest. Nickel and the two noble elements, palladium and platinum, appear in the same VIIIa group in the periodic table and consequently are similar in atomic structure; each has an incompleted d band. It is interesting to note what happens when each of these elements are alloyed with their corresponding neighbor in the Ib group, copper, silver, and gold, that have completed d bands. Fig. 7 shows results for the Ni-Cu, Pd-Ag, Pd-Au, and Pt-Au systems. Based on this data, it appears that in each case the thermoelectric power is made more negative with respect to platinum up to about 50 atomic per cent addition of alloying elements located to the right in the periodic table. Above 50 per cent, additions are from elements to the left in the periodic table and the thermoelectric power becomes increasingly more positive. In addition, the alloy of 40% palladium and 60% gold, for example, has an extremely high thermoelectrically negative output, approximately six times that of alumel at 900 C.

On the basis of the above, it appears there is a favorable possibility of extending the usefulness of thermocouples by the development of noble metal thermoelements possessing the important combination of improved thermoelectric output, measurement of high temperatures, and superior stability.

An attempt has been made in this direction in endeavoring to develop a reliable thermocouple temperature-measuring system for pre-turbine installation in aircraft jet engines. The work done made use of available noble metals and their alloys to perfect a system that would operate over the range of temperatures from 950–1300 C for 400 hr in an atmosphere of combusted hydrocarbons while maintaining an accuracy of $\pm 0.5\%$. In so doing, advantage was taken of the relatively high thermoelectrically negative output of palladium (Fig. 8), and the relatively high thermoelectrically positive output of a platinum — 15% iridium alloy (Fig. 9).

The combination of these two materials produced an output of approximately three times that of platinum — platinum-10% rhodium and three-quarters that of chromel-alumel. Also developed were a nickel-silicon alloy and a nickel-chromium alloy for use as lead wires that closely matched the output of the thermoelements up to about 800 C.

Combustion chamber test results using JP-4 fuel (Fig. 10) indicate that the 0.5% limit of accuracy was maintained and stability compares favorably with the platinum-platinum-13% rhodium system.

To Order Paper No. 105V ...
... on which this article is based, turn to page 6.

How to Calculate Truck Transmission Gear Life

Based on paper by

F. C. Meldola

New Process Gear Division, Chrysler Corp.

THE gradeability formula can be used as the basic means for rating a truck transmission. By correlating the gradeabilities in the various gear ratios with a highway requirement probability curve, the per cent of time in each ratio can be obtained. The required hours of gear life for each ratio are then determined, and compared with the available gear life in the ratios.

This procedure gives a detailed analysis of a transmission rating for one vehicle specification at a specified mileage between overhauls. . . . But it does not lend itself to fast application of various vehicle specifications. To do this, a nomogram may be constructed from the results of a few calculations for well-chosen specifications.

Use of Gradeability

The first step is to calculate the gradeabilities in all gear ratios for a set of vehicle specs.

$$\text{G.A.} = \frac{T \times R_t \times R_r \times E \times 1200}{r \times \text{GVW}} - L$$

Where:

- G.A. = Per cent gradeability
- R_t = Transmission ratio
- R_r = Rear axle ratio
- E = Drive-line efficiency (taken as 0.9)
- r = Tire rolling radius, in.
- GVW = Gross vehicle or combination weight
- L = Rolling resistance in per cent grade (taken as 1.25)
- T = Average applied engine torque (average of max net torque and net torque at governed engine speed), lb-ft

Next, the per cent time more gradeability required is obtained from Fig. 1 — a probability curve for normal and severe highways, and express turnpike. It is a universal curve for truck applications.

The per cent of total time in each ratio is arrived at by subtracting successively from 100% the per cent time more gradeability required.

To find the total time in all ratios, an arbitrary figure of 100,000 miles of gear life is assumed. The

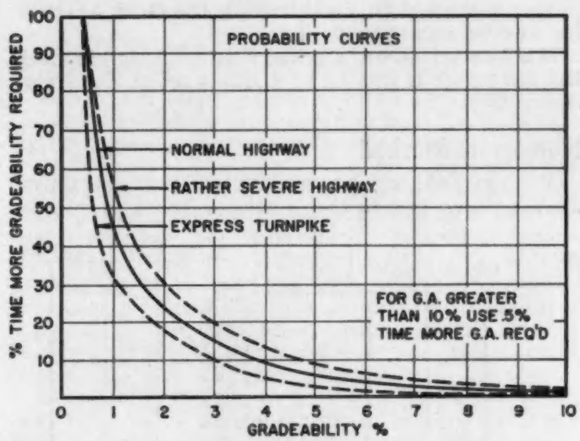

Fig. 1 — Gradeability versus per cent time more gradeability required. Curves are based on gradeability calculations and test data. Different tractor-trailer combinations were tested over various highways, and the time in each transmission ratio was clocked and expressed as a percentage of the total trip time. These figures were then matched to the calculated net gradeabilities for the gear ratios in each vehicle. By starting with 100% and subtracting successively the per cent time in each gear ratio for each test vehicle, the continuous curves were obtained.

average vehicle speed for each ratio can be obtained from:

$$MPH_a = \frac{RPM \cdot r}{168 \cdot R_r} \times \tfrac{1}{2} \left(\frac{1}{R_{t'}} \; \frac{1}{R_{t''}} \right)$$

Where:

MPH_a = Average highway speed
$R_{t'}$ = Transmission ratio for required average speed
$R_{t''}$ = Next numerically larger ratio
RPM = Maximum governed engine speed

Then the total time in ratios (hours) is expressed as:

$$T = 100{,}000/(A \times B,\ 1st + A' \times B',\ 2nd + A'' \times B'',\ 3rd + \ldots etc.)$$

Where:

A = Per cent of total time in each ratio
B = Average vehicle speed in each ratio
1st, 2nd, 3rd = Indicators of gear ratios — not used in equation

The required hours of gear life for each ratio equals the product of total time and per cent of total time in each ratio. To compare it with the available gear life in the ratios, two types of gear tooth failure are considered:

(1) Failure of the gear teeth by fatigue — usually shown by a progressive crack and ultimate breakage at the root of the tooth.

(2) Failure by compressive stress on the gear teeth surface (pitting).

The required hours for any one ratio must be equal to the available hours in the corresponding ratio . . . and all other required hours must be equal to, or less than, the available hours for the corresponding ratios.

(When failure by compressive stress is a ruling factor, use the driving gear only for comparison.)

If the above conditions are not met, by trial and error select a gross vehicle weight (GVW) or gross combination weight (GCW) which will give the proper balance. This will then be the GCW or GVW for one vehicle specification.

If a 2-speed axle or auxiliary transmission is used, the low range is treated as another set of transmission ratios.

Nomogram Method

A nomogram can be constructed from calculated curves which box in the practical limits of vehicle specifications. The following curves are required:

(1) GVW or GCW versus rear axle ratio.

(2) GVW or GCW versus maximum net engine torque.

(3) GVW or GCW versus gear life.

Curves (1) and (2) are based on 100,000 miles between overhauls.

Fig. 2 shows a nomogram. For any vehicle specification the rating of a particular transmission may be obtained in GVW or GCW for 100,000 miles of gear life (for normal highway operation). By holding the point on the GVW or GCW scale for 100,000 miles of gear life, the gear life for any other GVW or GCW is obtained (as increased or decreased miles of life from the gear life scale).

To construct the nomogram, the line spacing is arbitrary. Spacing in proportion to that shown in Fig. 2 has proved to be very satisfactory.

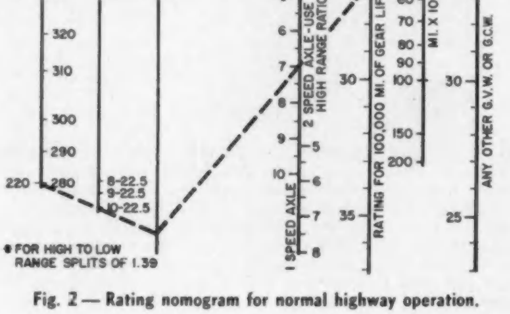

Fig. 2 — Rating nomogram for normal highway operation.

How to Construct Nomogram

1. Lay in single speed rear axle scale at any convenient equal spacing.

2. From curve (1), mentioned above, use the maximum net torque. This represents the average net torque which was used to calculate the curve. Place a point on the nomogram engine maximum net torque line and label it. From this point, using a straight edge, strike off a point at any convenient position on the reference line, and the corresponding point on the tire line. Label the point on the tire line with the basic tire size.

Using the basic tire size on the curve, select a GVW or GCW and its corresponding ratio. Draw a line from the point on the reference line through the axle ratio scale at the proper ratio. Where it intersects, the GVW or GCW rating scale defines a rating. Continue this process until the GVW or GCW rating scale is complete.

For other tire sizes, select a GVW or GCW and its corresponding ratio. Line up these points with a straight edge and strike off a point on the reference line. Line up this point with the original point on the maximum net torque line. Strike off a point on the tire line and label it with the tire size.

3. From curve (2) select maximum net engine torque and corresponding GVW or GCW for the axle ratio and tire size. Line up a GCW and the axle ratio. Strike off a point on the reference curve. Line this point up with the tire size and strike off a point on the maximum net torque line. Continue this process until the engine maximum net torque line is completed.

4. From curve (3) construct the any-other-GVW or -GCW scale by making divisions equal and in line with those on the GVW or GCW rating scale for 100,000 miles. Invert the scale figures as shown.

Select the GVW or GCW at 100,000 miles of life. Place a straight edge at this point on the GCW rating line for 100,000 miles and the same GCW of the any-other-GVW or -GCW line. Strike off a point on the gear life line and label it 100,000 miles. Retain the same point on the GVW or GCW rating line for 100,000 miles; select other GVW or GCW for the any-other-GVW or -GCW line and mark off the corresponding miles of gear life on the gear life line.

To Order Paper No. 76U . . .
. . . on which this article is based, turn to page 6.

How to Gain or Lose with Diesel Turbocharging

Based on paper by

E. B. Ogden, Consolidated Freightways, Inc.

Table 1

Cost Comparison Between Naturally Aspirated and Turbocharged Engines in Western 4 x 4 Operation for 1956

Cummins NH Engines		
Total Distance, miles	5,887,078	
Fuel, cost per mile		\$0.052506
Lube Oil, cost per mile		0.000907
Engine Maintenance, average cost per mile		0.004718
Total Cost of Fuel, Oil, Maintenance per Mile		\$0.058131
Cummins NT Engines		
Total Distance, miles	9,472,781	
Fuel, cost per mile		\$0.051765
Lube Oil, cost per mile		0.001346
Engine Maintenance, average cost per mile		0.009082
Total Cost of Fuel, Oil, Maintenance per Mile		\$0.062193
Additional Cost Per Mile NT Engine Over NH Engine		
Actual		\$0.004062
If Turbocharger Claims Not Allowed		0.007805

Warranty on turbochargers is actual amount received and applied to total turbocharged engine mileage.

IN THEORY and in practice, turbocharging a diesel engine will save on fuel since the energy used to drive the turbocharger is waste energy. The saving shows up as an increase of about 10% in horsepower. However, if the turbocharger is used to get still more horsepower, the efficiency of the engine drops off as the power increases.

If, for example, you take a 200-hp engine, install a turbocharger and do not change the fuel setting, you will get approximately 220 hp. This is desirable because it doesn't cost any extra fuel, provided it does not result in increased maintenance for turbocharger and other engine parts because of the power increase.

On the other hand, if you were to increase the fuel setting until the engine delivered 250 hp, you would note a decrease in the fuel economy of the vehicle per mile. Engine fuel curves per horsepower do not show this to be true; actual practice indicates that it is. It is normal to feel that with more power you would traverse the route much faster. That's wherein the danger lies. Does it pay to cover the route faster, or does it just give the drivers more time for coffee stops? What good does it do to have a vehicle at its destination say at 6 a.m. with a high-powered turbocharger as against 7 a.m. with a naturally aspirated engine if the vehicle is not going to be worked until 8 or 8:30 a.m.?

Finding out the hard way

Like most operators, we were convinced that we needed higher horsepower and that it would save enough driver overtime, among other things, to pay some of the extra cost of installing turbochargers. After a year and a half of operation, when cost figures were old enough to be compiled, we saw the light and started immediately to remove the turbochargers. Table 1 shows comparative costs.

Higher powered engines will be needed

Before too long, higher powered engines may be needed to traverse toll roads and possibly the interstate highway system with considerably heavier loads than are now hauled. A very successful test has convinced New York Thruway authorities that gross loads of 130,000 lb and lengths of 98 ft were entirely feasible upon this superhighway and several operators are taking advantage of it. To do this they must have more powerful vehicles, capable of climbing any grade at 20 mph and maintaining at least 45 mph on the level, which are the requirements. This takes horsepower in the 275–325 class, and here's where turbocharging may pay its way.

We are now trying to find a turbocharger which will have more dependability at considerably less cost than those originally furnished us, and at much less cost if purchased outright. There seems to be a good chance of achieving this goal.

Turbochargers are probably the easiest way to increase horsepower, but be sure you need the extra horsepower before you buy turbochargers.

To Order Paper No. 87T . . .
. . . on which this article is based, turn to page 6.

Simplicity, accuracy, and reliability feature

New instrument for measuring surface ignition

Based on paper by

K. Hyatt, V. J. Tomsic, and C. A. Mellinger

E. I. du Pont de Nemours & Co., Inc.

AN electronic instrument for assessing the prevalence of surface ignition in unmodified engines of late model cars has been developed by the du Pont Petroleum Laboratory. It is reliable, generally more sensitive than ionization gaps, and measures very accurately the time in crankangle degrees between spark ignition and peak pressure for each combustion cycle with wide-open throttle acceleration of a multicylinder engine. It can also be used to study a single-cylinder engine.

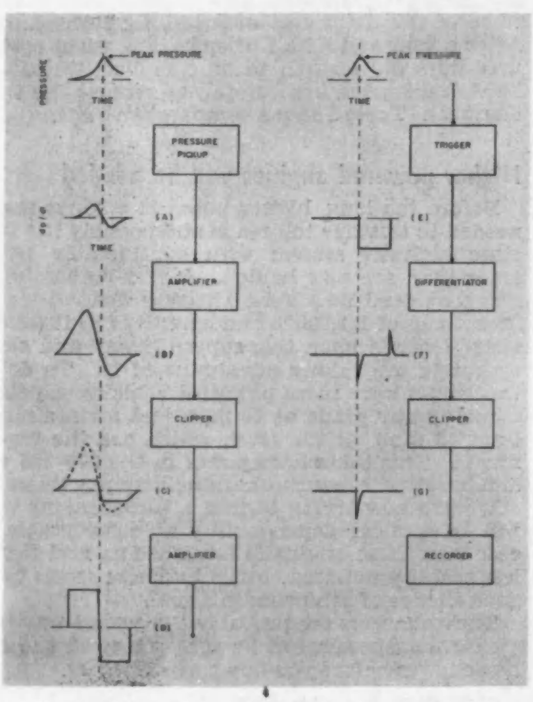

Fig. 1 — Basic electronic components in an instrument for accumulating peak pressure occurrence data from a single cylinder.

Data accumulation

The basic electronic components for accumulating peak pressure occurrence data from a single cylinder are shown in Fig. 1. Cylinder pressures are meassured by miniature SLM PZ-6 piezoelectric pressure transducers integrally mounted in standard spark plugs. Cylinder pressure development is sensed by the pickup through a connecting passage drilled through the body of the spark plug. In all cases, the spark plug normally recommended for the engine under test is modified to receive the pressure pickup.

For convenience, a signal of the rate-of-pressure change with respect to time (dp/dt) is utilized rather than a pressure-time signal. Components (B) through (E), representing the various stages of a peak pressure pulse generator, produce an electrical pulse coincident with peak pressure. The dp/dt signal (A) is amplified (B) and then symmetrically clipped (C). The clipped dp/dt wave form (C) is further amplified (D) and a pulse (E) is triggered at the zero crossing point. The squared electrical pulse (E), the leading edge of which is coincident with peak pressure occurrence, is differentiated (F), and the positive pulse is removed by a diode clipper. The negative pulse (G), which is coincident with the time of peak pressure occurence, is then recorded on one channel of a magnetic tape recorder.

Separate pickups and peak pressure pulse generators are used for each individual cylinder (Fig. 2). Signals from the eight channels are combined into a single channel for recording. This is done with an electronic commutator indexed to the proper input channel by the primary ignition pulse from the cylinder in which combustion is taking place. A means is provided for keeping the commutator synchronized with engine operation.

Another pulse generator produces a pulse coinci-

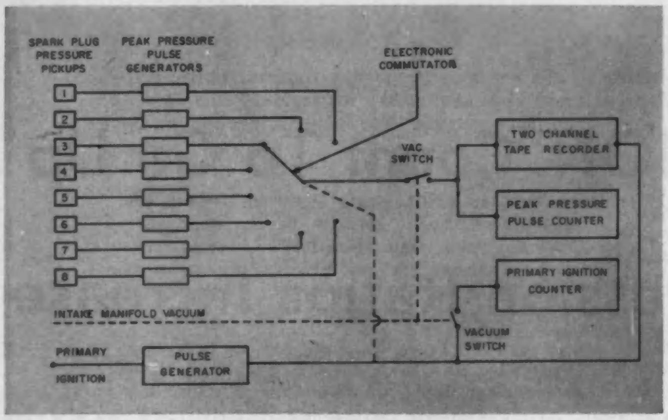

Fig. 2 — Separate pickups and peak pressure pulse generators are used for each cylinder in a multicylinder engine.

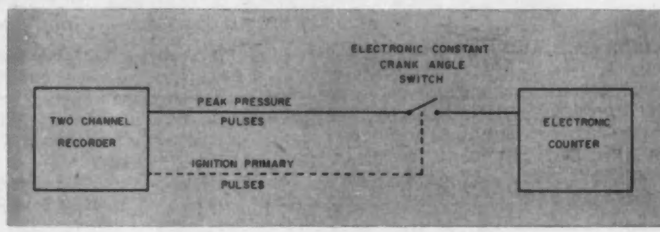

Fig. 3 — Basic electronic components required for converting the peak pressure occurrences from the two-channel magnetic tape recorder into usable data.

dent with the opening of the distributor points and thus coincident with spark timing. This pulse is recorded on a second channel of the magnetic tape recorder. A vacuum switch in series with the electronic commutator and recorder permits recording of peak pressure pulses only during maximum-throttle operation of the test vehicle, that is, 4 in. of Hg manifold vacuum, or less.

Two electronic counters monitor the instrumentation during data accumulation. The total number of peak pressure pulses and the total number of primary ignition pulses are registered on the counters during maximum-throttle operation. Agreement of the totals indicates that the various stages of the instrumentation used for data accumulation are operating properly. Although not developed for such purposes, the instrument is also a very sensitive misfire detector, since misfire cycles will show up as peak pressure pulses at top dead center and can be counted separately.

Process of data reduction

The basic electronic components for converting the peak pressure occurrences from the tape recorder to usable data are shown in Fig. 3. The primary ignition pulses recorded on the tape actuate an electronic constant-crankangle switch. The switch is closed by the primary ignition pulse and remains so for a preset number of crankangle degrees. The negative pulses (coincident with peak pressure) that occurred in this crankangle interval are registered on the electronic counter, the total count at a given crankangle setting being the number of cycles giving peak pressure between ignition and the given setting. The magnetic tape is passed through the read-out section of the instrument several times at different crankangle settings to give a complete picture of the distribution of peak pressure times.

The addition of eight counters to the read-out section of the original instrument described here allows peak pressure time distributions to be obtained for each cylinder of a multicylinder engine and so increases its usefulness.

The combined variability of the instrument, apart from any engine and pressure pickup variabilities, is less than ± 0.1 of a crankangle degree or about 0.000005 sec at 3200 engine rpm.

Results of tests

This instrument has been used to determine the incidence of total surface ignition in 97 privately owned 1957–1958 model cars selected to represent the total distribution of cars on the road for these two model years. Some of the findings were:

1. More than half the cars had an instrumentally detectable amount of surface ignition.
2. More than 10% of the cars gave audible evidence of surface ignition on tank fuels.
3. Combustion-chamber design or other mechanical factors may have a greater influence on the occurrence of surface ignition than do combustion-chamber deposits.
4. Controlled laboratory tests of additive effectiveness may not be indicative of field performance in consumer hands.

To Order Paper No. 78U ...
... on which this article is based, turn to page 6.

SURFACE IGNITION Count To Go Up As Compression Ratios Increase

• Surface ignition and engine noise problems are likely to become more acute as compression ratios move up, consumer-type studies indicate

Based on paper by

S. Hopkins, R. J. Pecora, and N. Alpert

Texaco, Inc.

RECENT tests using four different combustion-chamber shapes — and several fuels — show how surface ignition and resulting noise are measurably affected by combustion-chamber design . . . and high compression ratios.

From testing these four shapes in 1958 vehicles and in 12/1 compression ratio vehicles, it appears that:

• Hemispherical and inverted-V combustion-chamber engines are superior to the wedge type in controlling surface ignition and resulting noise in the 1958 vehicles.

• In the 12/1 compression vehicles, the hemispherical is superior to the wedge as regards noise . . . and the inverted-V is superior to the wedge on surface-ignition count.

• Increasing the aromatic content from 0 to 30% ups both surface ignition and induced noise in the 12/1 vehicles . . . while 30–40% aromatic content increase in the 1958 vehicles brings greater surface ignition and noise only in the wedge-type combustion-chamber vehicles.

• Phosphorous fuel additives are effective in reducing the level of surface ignition, but are not a complete cure.

What happens as regards surface ignition and noise ratings in the 1958 and the 12/1 compression ratio vehicles with 30% aromatic fuel is shown in Fig. 1.

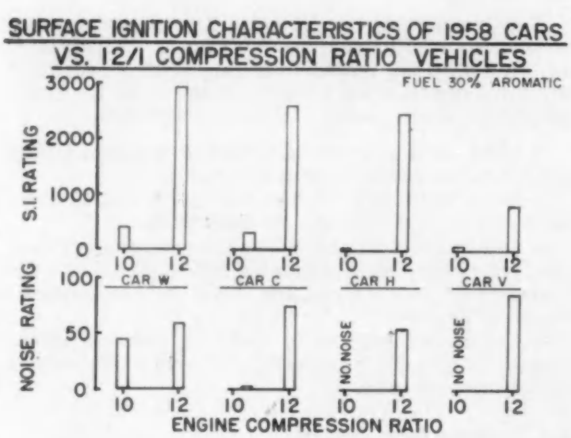

Fig. 1

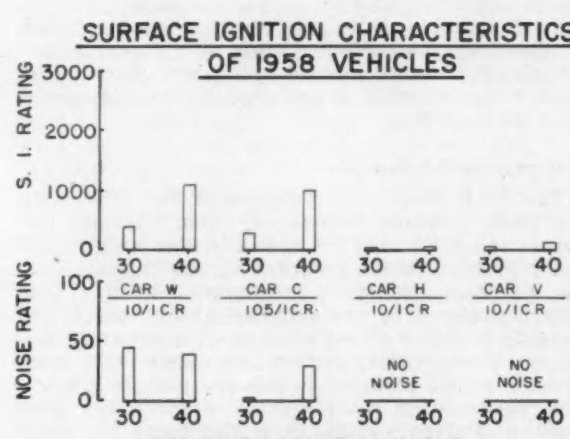

Fig. 2

THIS article summarizes instrumented and consumer-type (subjective) evaluations of surface ignition and surface ignition-induced noise in passenger cars.

As a consumer-type study, these evaluations were conducted in vehicles. So, the surface ignition ratings — and particularly the noise ratings — (which evaluate the performance of several combustion-chamber configurations) may also reflect other engine, body, and chassis differences.

Four popular makes of 1958 cars with overhead-valve, V-8 engines were used for the road test fleet. . . . The 12/1 conversions were purchased from the manufacturers as complete assemblies in two cases . . . machined and assembled according to the manufacturer's instructions in another case . . . and converted with pistons of Texaco's own design in the other.

Fuels used in testing the 1958 cars were: (1) a 30% aromatic blend of C_4 alkylate and heavy catalytic reformate, 103 Research octane, and (2) a 40% aromatic blend of light fluid cracked naphtha and catalytic reformate, 102 Research octane.

In testing the 12/1 compression ratio cars, the fuels used were: (1) a C_4 alkylate, 105 Research octane, and (2) a 30% aromatic blend of C_4 alkylate, light fluid cracked naphtha and heavy catalytic reformate, 103 Research octane. This latter fuel also served as a base fuel for additive and additive concentration studies for phosphorous surface control additives.

In most cases, compression ratio increase from the 10/1 to 12/1 area brought a large increase in both surface ignition count and noise. . . . Every one of the 12/1 engines produced more noise than their 1958 counterparts . . . and much more than the motorist is likely to tolerate. Two of the 1958 engines (the hemispherical and inverted-V types) produced no noticeable noise

Figs. 2 and 3 show effects on surface ignition and engine noise ratings of various other aromatic fuel blends. In three of the four 12/1 compression ratio engines, even leaded alkylate produces objectionable engine noise. . . and both surface ignition and noise rating response of a 30% aromatic fuel to a phosphorous additive seem to vary in the different 12/1 engines

Other fuel additive effects shown in Fig. 4 result from studies conducted with four of the 12/1 cast-wedge combustion-chamber engines . . . the engines which produce the most severe surface ignition count.

Here it is indicated that surface ignition decreases with increased phosphorous concentration. The suppression effect, however, is not proportional to the amount of phosphorous used. Also, it appears, phosphorous additives differ slightly in their suppressing effect . . . and the suppressing effect with such additives is usually accompanied by a corresponding decrease in engine noise.

In further tests of phosphorous additives, a non-additive base fuel evaluation was extended beyond its normal termination after 0.4 theory phosphorous was added to the fuel. Surface ignition ratings showed that after 2500 miles of deposit accumulation with a non-additive base fuel, an additional 1000 miles of deposit accumulation and displacement was required before the phosphorus began to have a significant suppressing effect.

To Order Paper No. 78V . . .
. . . on which this article is based, turn to page 6.

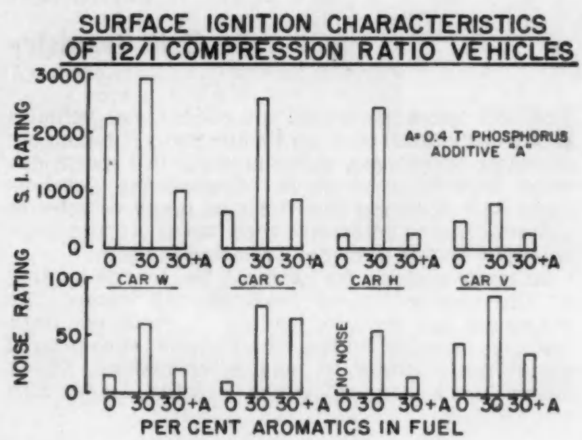

Fig. 3

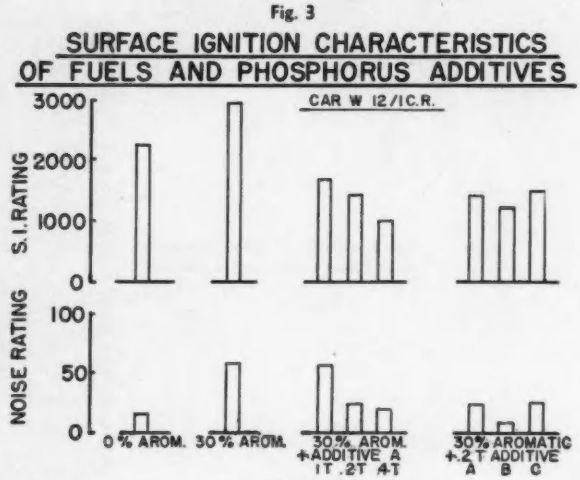

Fig. 4

GOVERNORS Help Most

in engine and chassis areas where uncontrolled speeds develop harmful heat loads

Based on paper by

G. R. Beardsley

Ford Motor Co.

ENGINE speed governors for commercial vehicles are economical controls for the many components in engine and chassis where uncontrolled speeds develop harmful heat loads. Engineering development data gathered from tests on many vehicles of different makes points out these areas . . . and indicates the engine governor's relation to them.

In many engines, for example, the inertia loading of the connecting-rod bearings will exceed the maximum gas pressure loading . . . with resultant bearing stresses higher than those encountered under peak torque or lugging operation. Fig. 1 shows these connecting-rod bearing loads with wide-throttle operation combining gas pressures and minus inertia forces. It compares inertia forces which exist under deceleration loads, shifting operation, and part-throttle conditions.

Fig. 2 shows clearly that, in the normal operating range, the oil pump capacity of this particular engine is adequate to meet the requirements, but that, at higher speeds, the oil supply diminishes.

That the efficiency of the water pump decreases and the heat output of the engine increases at higher temperatures is shown in Fig. 3. (In this engine's normal operating range, the water flow is essentially a straight-line function, and would remain so at the higher speeds if the water temperature were maintained up to 160 F.)

Fig. 4 illustrates the effects on valve-seating velocity of engine speed. High stresses in valve trains result in tappet pitting, camshaft wear, and valve-

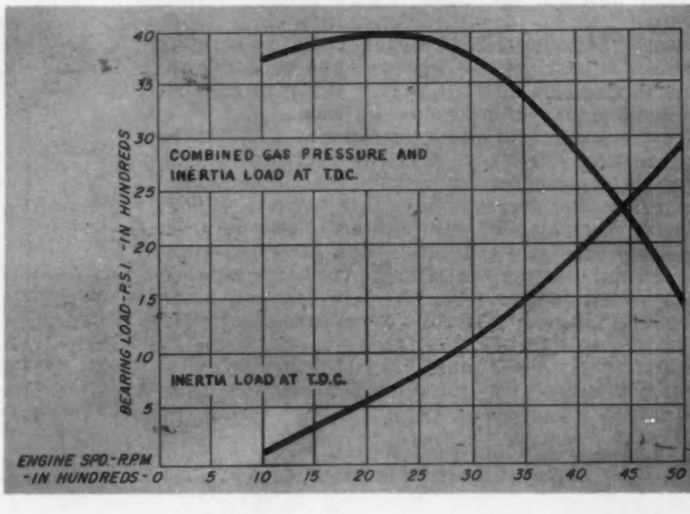

Fig. 1 — Connecting-rod maximum bearing load versus engine speed.

TODAY'S GOVERNOR has to govern engines from the smallest sizes up to 800 hp . . . on vehicles grossing less than 1 ton and over 60 tons. It must govern vehicles in forward and reverse motion; must govern accessory units with the vehicle stationary or in motion . . . and still protect the engine.

Today's governors for over-the-road vehicles are of three basic types:

- Straight vacuum velocity type.
- Centrifugal *vacuum* type.
- Centrifugal *mechanical* type.

The straight vacuum velocity governor is often called the "sandwich" type because it is sandwiched between the intake manifold and the carburetor. It is a secondary throttle plate centered in an orifice and attached to a cross shaft mounted in antifriction ball bearings on either end. The velocity of the fuel and air mixture through the orifice and against the plate tends to close (and would close) the valve were it not for the opposing action and force of a governor spring — which opens the valve at all speeds lower than the governor setting. A nearly constant engine speed is maintained whether the engine is running with or without load.

The centrifugal vacuum type is usually of integral construction with the carburetor and uses the engine vacuum at the venturi and below the throttle plate as the primary force. Another device used in conjunction must regulate and control the amount of vacuum required.

The centrifugal mechanical governor regulates the engine speed automatically. Properly linked to the carburetor, it automatically opens and closes the carburetor throttle valve at the exact instant to give the engine fuel in the correct proportion to meet the load demand and speed requirement. The engine is never permitted to drop below the governed speed; never, therefore, required to accelerate under load.

(The full story of today's governors — from which the above information was abstracted — is told in papers by Fred Hague, Sun Oil Co. (Paper No. 80T); G. D. Hedden, Hoof Products Co. (Paper No. 80W); R. G. Morey, King-Seeley Corp. (Paper No. 80X); M. F. Sterner, Holley Carburetor Co. (Paper No. 80V); L. E. Bradnick and L. E. Boren, Pierce Governor Co. (Paper No. 80Y); and P. N. Hanebuth, Stewart Warner Corp. (Paper No. 80Z) . . . To order any of these papers, turn to p. 6.)

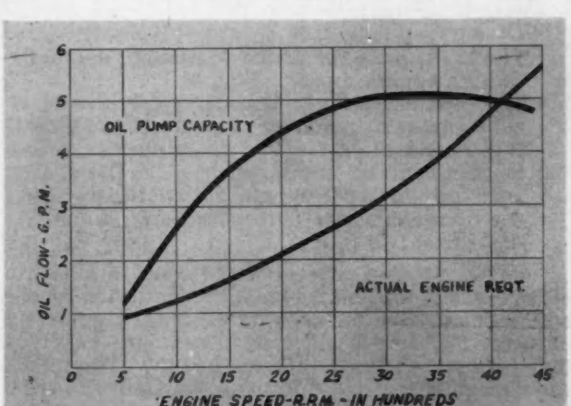

Fig. 2 — Oil pump delivery versus speed.

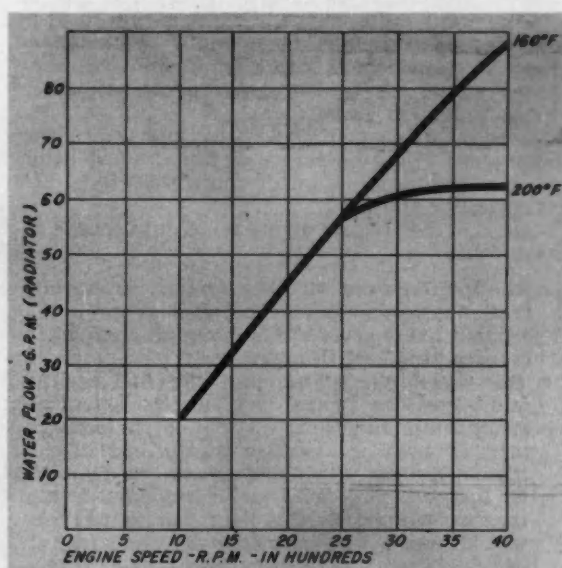

Fig. 3 — Water pump delivery versus speed.

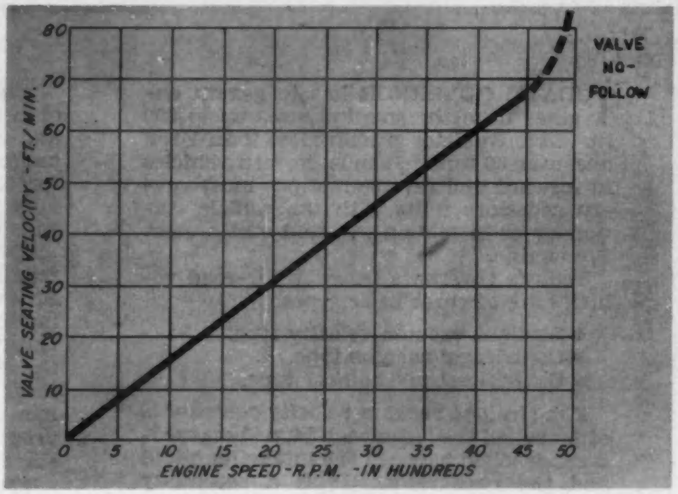

Fig. 4 — Valve seating velocity versus engine speed.

head failures. Velocities may exceed safe operating levels at excessive speeds . . . and, in particular, during valve no-follow or valve toss conditions. This example is indicative of the stress levels in the valve train. All the valve components respond similarly to the adverse effects of overspeeding.

Fig. 5 shows that piston speed is directly proportional to engine speed. Engine durability — and the piston and engine oil-control areas — are directly related to piston speed. Wear rates on pistons and rings are greatly increased with high piston speeds, and may be effectively reduced with speed control. The durability objectives of engines are limited by deterioration of these reciprocating components.

The kinetic energy dissipated in stopping a vehicle greatly increases with speed. Fig. 6 shows that the energy is greatly increased after 30 mph; in fact, at 60 mph approximately 3⅓ times the energy must be dissipated as compared to 30 mph. This kinetic energy is transformed into heat and has a detrimental effect on vehicle components, especially brakes, tires, and suspension.

The adverse effects on the engine and vehicle discussed above can be separate or combined, depending upon the basic design of the components, and driver skill or abuse.

Studies of fuel requirements relative to speeds indicate that:

- The fuel required with high engine speeds contraindicates economical operation (Fig. 7). The friction horsepower, inherent in all engines, increases rapidly with speed.
- The wheel horsepower and the fuel requirements in the typical vehicle are essentially straightline functions up to and including 30 mph (Fig. 8) . . . but are greatly increased at higher speeds. (To drive equivalent distances, for instance, 60% more fuel is needed at 50 mph than at 30 mph. So, it is clear, controlled speeds will improve fuel economy by reducing the power needed.)
- Increasing engine speed from 3000 to 4500 rpm (50%) requires about 3¼ times as much fuel.

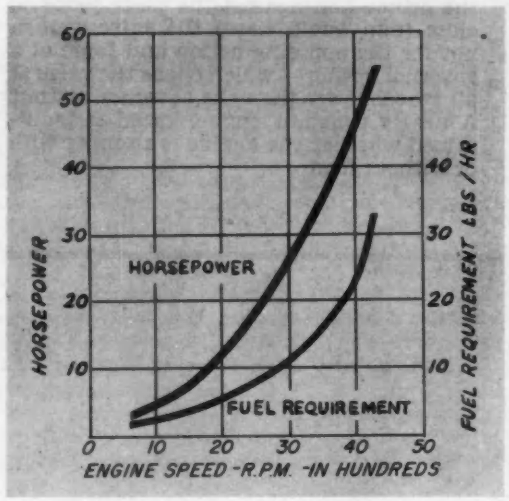

Fig. 7 — Friction horsepower and fuel requirement versus engine speed.

That's the price that must be paid for operating at high engine speeds. (Fig. 9)

- The brake specific fuel consumption should be kept as low as possible. Fig. 10 charts typical fuel island plots for fuel requirements versus horsepower and engine speeds. A thoroughly adequate governor should automatically select the optimum brake horsepower requirement at any speed. (Fig. 10)

Properly applied governors can help to alleviate all of these conditions in which uncontrolled speeds can develop harmful consequences in engine and chassis. The many governor advantages for commercial vehicles can be summarized as: (a) improving durability and (b) improving economy.

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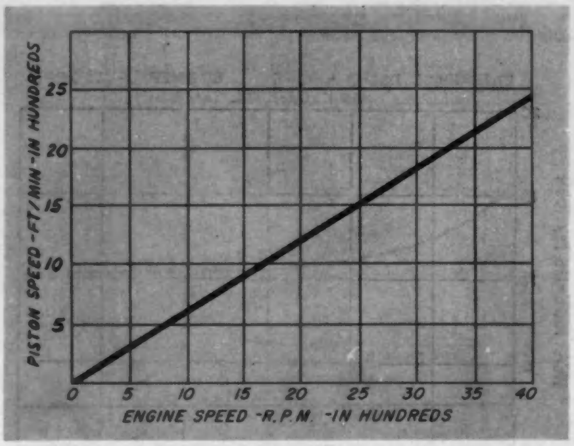

Fig. 5 — Average piston speed versus engine speed.

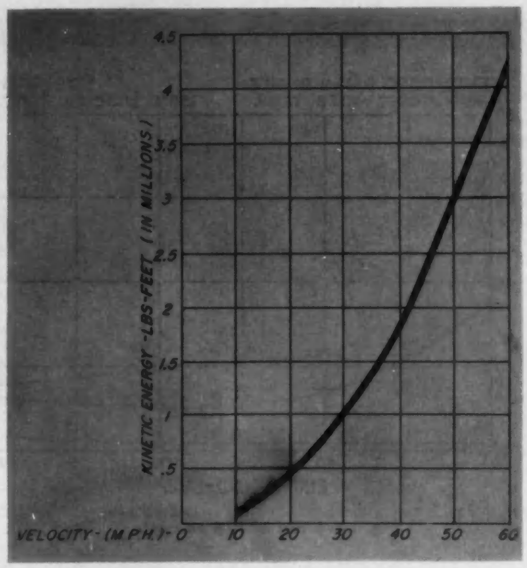

Fig. 6 — Required vehicle "stopping" force versus miles per horsepower. (gcw = 35,000 lb)

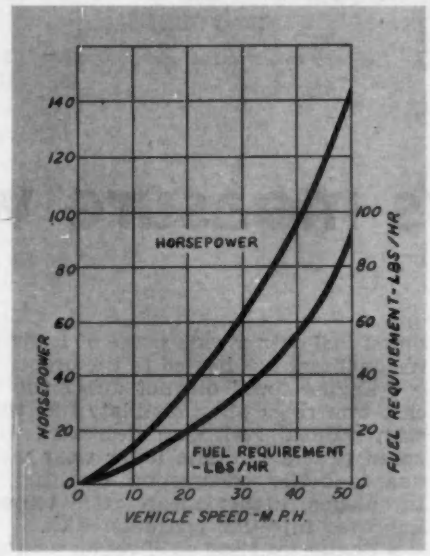

Fig. 8 — Roadload horsepower and fuel requirement versus vehicle speed. (gcw = 55,000 lb)

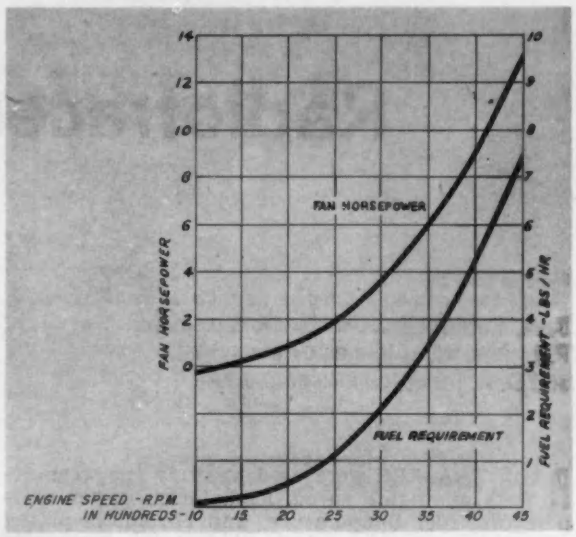

Fig. 9 — Fan horsepower and fuel requirement versus engine speed.

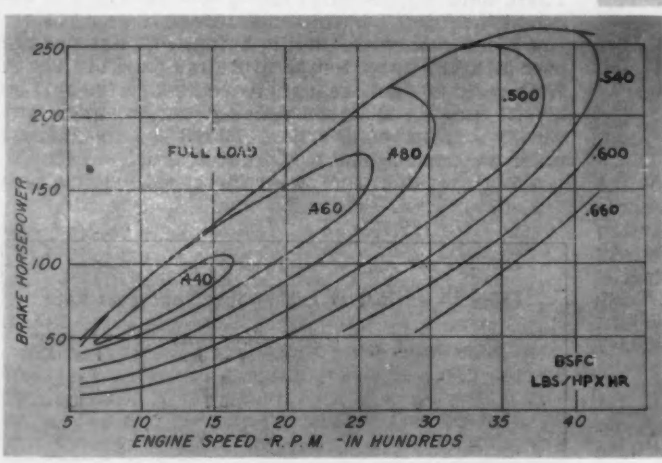

Fig. 10 — Typical fuel island plot of fuel requirements versus horsepower and engine speed.

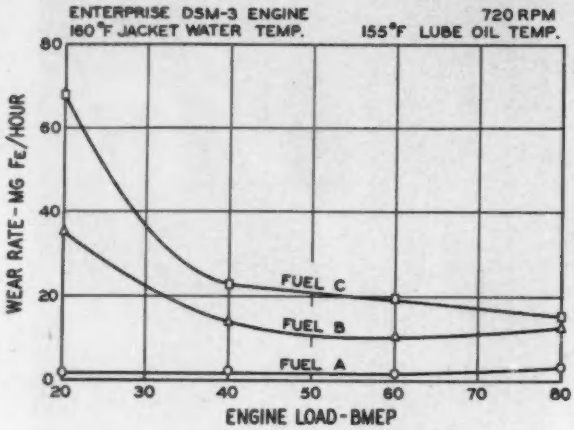

Fig. 1 — Effect of load on wear.

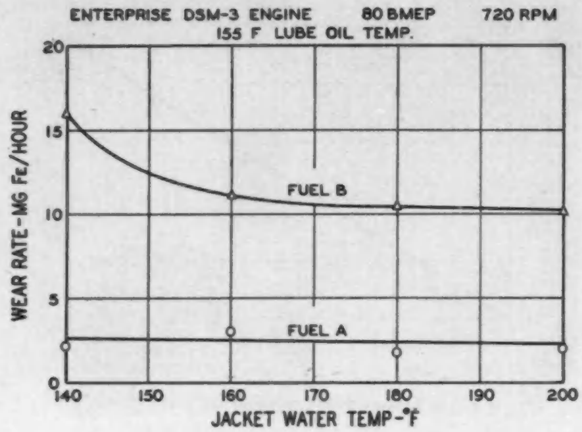

Fig. 2. — Effect of jacket water temperature on wear.

Radiotracers measure wear

Based on paper by

B. A. Robbins, Enterprise Division, General Metals Corp.,
P. L. Pinotti, Standard Oil Co. of California,
and D. R. Jones, California Research Corp.

RADIOTRACERS were used to study the wear effects of engine speed, load, jacket water temperature, fuel temperature, and chromium-plated rings on medium-speed diesel engines. The fuels tested were (1) a distillate diesel fuel (Fuel A), (2) a residual fuel of intermediate viscosity (Fuel B), and (3) a high viscosity residual fuel (Fuel C).

Tests with cast-iron compression rings

In this portion of the program, wear rates of the fuels were compared using standard cast-iron compression rings. For all tests on Fuel B, injection pump inlet temperature was held at 200 F. Except for tests on the effect of fuel temperature, Fuel C was tested at 250 F.

More than 85% of the total gravimetric weight loss on the rings was accounted for by radioactive measurements.

The results of this test program were:

- The brake thermal efficiency with high viscosity residual fuel was essentially equal to distillate diesel fuel over a wide range of loads, provided the residual fuel was heated to the proper temperature.
- Engine speed did not affect the wear rate of cast-iron rings when distillate fuel was used. But with residual fuel, wear decreased with increased speed (Table 1). The lower wear may have been due to better combustion resulting from higher turbulence, higher mean cycle temperature, and improved injection characteristics.
- Engine load had no effect on wear with distillate fuel. But with residual fuel, decreasing engine load produced a marked increase in ring wear (Fig. 1). These data suggest that minor amounts of the residual fuels didn't burn completely at higher loads.
- Wear rate with distillate fuel did not change over a jacket water temperature range of 140–200 F. With residual fuel, wear increased below 160 F (Fig. 2). It may be that the reduced temperatures adversely affected combustion of Fuel B near the cylinder walls considerably more than Fuel A.
- With residual fuel, wear increased below a cer-

Table 1 — Effect of Engine Speed on Wear Rate

Engine Speed, rpm	Wear Rate, Fuel A	mg Fe/hr Fuel C
720	3.2	15.6
900	3.2	10.0

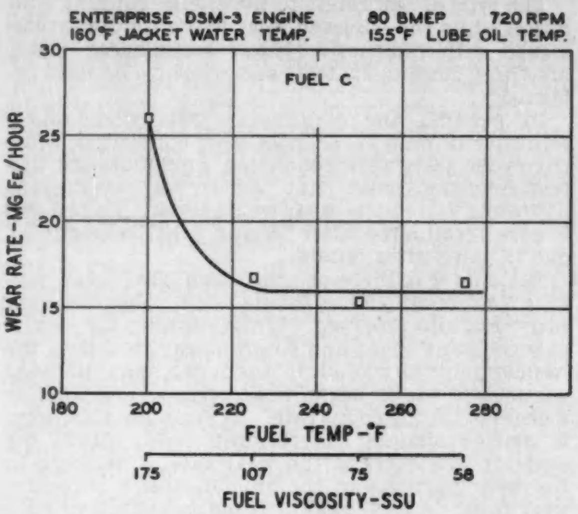

Fig. 3 — Effect of residual fuel temperature on wear.

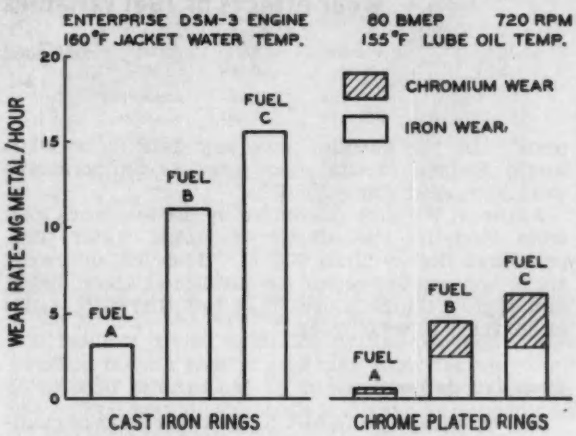

Fig. 4 — Wear rates with cast-iron and chromium-plated rings compared.

effects of fuel variables

tain minimum fuel temperature. This varies with fuel viscosity. Fig. 3 shows that with Fuel C, and at fuel temperatures below 225 F, wear rate increased markedly. As temperature was increased above 225 F, no further significant reduction in wear was observed.

Tests with chromium-plated rings

In the second phase of the program, tests were conducted with irradiated chromium-plated rings (face only) installed in the top ring groove of each piston. The plating affected wear as follows:

- It markedly reduced the wear with both distillate and residual fuels (as shown in Fig. 4). With all three fuels about half of the wear material was chromium (from the ring face) and half was iron (from the ring sides). So with residual fuels, which cause a large increase in wear, some means should be considered for reducing side ring wear as well as face ring wear.
- With residual fuel, the wear rate did not increase as load was reduced (Fig. 5).

Excerpts from Discussion

What happens to wear at 250 F water temperature?

Mr. Kuivinen: Installations are made today with pressure on the jacket so that water temperatures as high as 250 F are often encountered. Such installations are usually made for the purpose of supplying waste heat for other purposes within the

THIS IS the second of two papers on measuring engine wear by radiotracer techniques. Last month, Harry Halliwell, of the U. S. Naval Engineering Experiment Station, described how radiotracers revealed engine wear during a detergent oil filtration study.

This paper covers the wear effects of fuel variables. A 3-cyl Enterprise Model DSM-3 rated at 162 hp and 1000 rpm was used. The first phase of the program — with cast-iron compression rings — employed a conventional Geiger tube counting system.

In the second phase — using chromium-plated rings — samples of lubricating oil were drawn from the crankcase at scheduled intervals during each run. Each sample was placed in a special chamber and counted with a scintillation crystal.

Excerpts are also taken from the discussions by: T. O. Kuivinen, Cooper-Bessemer Corp.; C. K. Murphy and R. McClintock, General Motors Research Laboratories; W. C. Arnold, Fairbanks, Morse & Co.; R. J. Pocock, Ford Motor Co.; and Mr. Halliwell.

plant. Do the authors have any data as to what would happen to the wear rates as temperatures were increased above 200 F?

Authors: We were prevented by the test work load from studying the effects of jacket water temperatures higher than 200 F. However, our wear curve appears to become asymptotic at about 190 F, and higher temperatures may not therefore cause an increase in wear rates.

Wear particle loss

Messrs. Murphy and McClintock: We were particularly interested in the authors' statement that "more than 85% of the total wear . . . could be accounted for by radioactive measurements." This statement implies that almost 15% of the total wear could not be accounted for by radioactive measurements. This latter 15% is of special interest to us in that we at General Motors Research have also encountered this phenomenon, which we term "wear particle loss," while using radioactive tracer techniques in studying hydraulic valve lifter wear in a 1958 V-8 engine.

The detection system used was similar to that described by Mr. H. Halliwell in his paper.

When the radioactive wear values were compared to actual wear data obtained by weighing the irradiated lifters before and after the tests, some discrepancies were noted. In each test the radioactive wear figures were lower than the gravimetric wear determinations. This "wear particle loss" was not constant, however, but varied from 14 to 43%, as can be seen in Table 2.

The type of test refers to the engine running condition while the observed wear is the total wear obtained with radioactive tracer techniques. There are three continuous tests and three cyclic tests reported.

In general, the continuous tests were representative of mild valve lifter wear conditions, while the cyclic tests were conducted with lubricant and test conditions such that "severe" or catastrophic hydraulic valve lifter wear would occur. Tests 5 and 6 were terminated after 16 and 8 hr, respectively, due to valve lifter failure.

Not only was there as much as a 43% "wear particle loss" obtained but in one test a "negative wear rate" was also observed. While running the engine at a constant speed and continuously recording the radioactivity in the oil, it was noted that the wear particles in the oil began to decrease as indicated by a decrease in the count rate. In Fig. 6 the total wear is plotted against the running time. Since the slope of this curve is the wear rate, a decrease in the wear particles in the oil indicates a "negative wear rate." A total wear of 32 mg was obtained after one hour of operation. Subsequently, the total observed wear in the oil decreased for the next six hours operation. In addition, it required a total of 20 hr to obtain the same total observed wear as was obtained at the end of the first hour. The decrease in activity between one and six hr indicates "wear particle loss" which occurred in a continuous type test.

During the cyclic tests wear particle loss not only occurred in a running engine but was also obtained while the engine was shut off. Each cycle consisted of running the engine at 2500 rpm for 10 min after which the engine was shut off for 50 min. The oil was circulated continually through the counting and heat exchanger system. A baseline

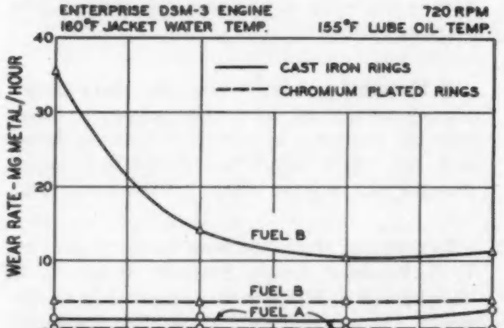

Fig. 5 — Effect of load on ring wear with cast-iron and chromium-plated rings.

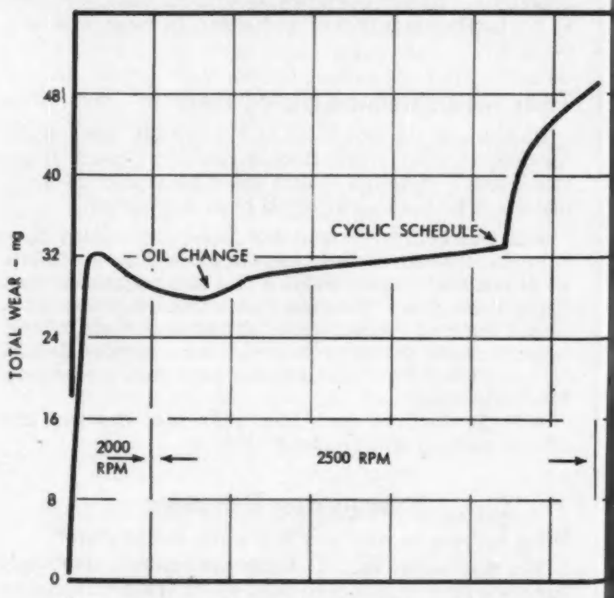

Fig. 6 — Hydraulic valve lifter wear.

count rate was obtained before each engine start with a continuous count rate being recorded during the complete cycle.

Fig. 7 presents the wear curves for three of the 16 cycles of Test 5. In this slide the count rate is plotted against time. Cycles 3 and 7 show the type of wear curves which might be expected in that the maximum count rate was observed at the end of the ten-minute run with no indication of "wear particle loss" during the run. However, during the shutoff time the count rate decreased, thus indicating a "wear particle loss" even when the engine is not running. This phenomenon was evident in 13 of the 16 cycles. In four of the cycles the "wear particle loss" appeared as negative wear rate during the ten-minute run and continued at the same apparent rate until the engine was restarted. Cycle 11 is typical of this and shows that maximum count rate was obtained after three minutes of running.

Even if one were to talk only about relative wear rates, wear data could be seriously in error if the wear particle loss is not completely understood.

Mr. Halliwell: Negative wear rates were observed during some of the early radioactive tracer studies at the Experiment Station. The cause was found to be the sensitivity of the scintillation crystal to temperatures over 135 F. When the lubricating oil in the counter well was maintained at a lower temperature, no further difficulty of this nature was experienced.

Authors: No information is available that would account for the 15% of the total wear debris not indicated in the lubricating oil. Possibly some or all of the unaccounted debris passed out with the exhaust gases; but we have no measurements to substantiate this.

Mr. Arnold: Radioactive tracer tests were made by Fairbanks, Morse & Co. to determine the proportions of the wear debris passing into the exhaust gas and lubricating oil of a 2-stroke diesel engine. From 10 to 40% of the wear debris was carried away in the exhaust gases, with the actual proportion depending on the engine load and other factors. The total wear determined by radioactive tracer methods agreed very closely with the wear as determined by physical measurements.

Table 2 — Wear Particle Loss

Test No.	Test Type	Test Hours	Gravimetric Wear, mg	Radio-active Wear, mg	Wear Loss, %
2	Continuous	51	12.5	7.6	39
3	Continuous	150	43.6	25.2	42
4	Continuous	22	57.6	33.0	43
	Cyclic	5	20.8	15.9	24
5	Cyclic	16	635.6	506.4	14
6	Cyclic	8	408.0	350.0	20

Do cylinder and ring wear rates correlate?

Mr. Arnold: If the primary interest is cylinder liner wear, isn't the ring wear data obtained of limited usefulness? Is there any information available as to the relative wear rates of piston rings and cylinder liners?

Mr. Pocock: Fleet tests made by the Ford Motor Co. have shown very excellent correlation between the wear rates of cylinders and piston rings. Any factor that affected ring wear had a similar effect, in about the same proportion, on cylinder wear.

Authors: Ring and liner wear have been found to have close correlation. This has been substantiated by field experience.

To Order Paper No. 72U . . .
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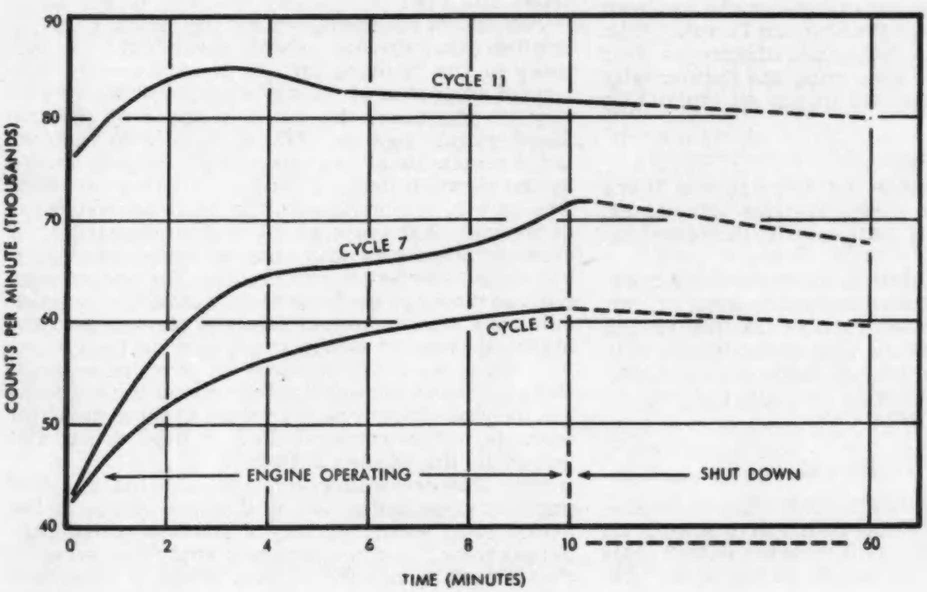


Fig. 7 — Cyclic wear.

French Develop Improved Radioactive Tracer Technique

Increased sensitivity and greater accuracy claimed for modified radiotracer technique for measuring piston-ring wear developed by Institut Français du Pétrole

Based on paper by

J. Thiéry

Institut Francais du Pétrole

A TECHNIQUE for determining piston ring wear by measuring the radioactivity of wear debris dispersed in oil leaving the cylinder walls has been developed at the Institut Francais du Petrole. This new method gives the following advantages over previous techniques for measuring the radioactivity of the wear debris dispersed in the oil circulating around a detector:

- Increased sensitivity.
- Permits more accurate, detailed analysis of the beginning of the wear curve, in order to establish startup wear. This is particularly important in many cases.
- Takes into consideration those particles eventually escaping with the combustion gases or embedded with lacquer or varnish in piston-ring grooves — in addition to the wear debris dispersed in the oil itself. The amount of these particles may vary with the type of oil being used and particularly with its detergency characteristics.

The Technique

The new method consists in measuring the radioactivity of the oil-containing debris that flows down along the cylinder wall. This "moving down" oil is collected in gutters at the bottom of the liner. It is then pumped from these gutters to a coil around a scintillator, and then returned to the sump. By properly designing this oil circuit, the activity and oil volume flowing around the scintillator during the test can be recorded. It is also possible to simplify the scheme so that, when flowing out from the scintillator coil, the active oil is received in a graduated vessel and then periodically returned to the sump.

Two counts are made, one for the "moving up" oil and the other for the "moving down" oil. The activity of the "moving up" oil is continuously subtracted from that of the "moving down" oil by putting in opposition the outlet voltages of the two identical rate meters. This difference in radioactivity represents at any moment the activity gained by the oil when flushing through the ring belt area. The gain is proportional to the instantaneous wear of the ring that occurred a few minutes earlier. A constant wear rate may thus be represented by a vertically recorded curve (Fig. 1). For comparative studies, it may be useful to deduce from the recorded curve of a test the actual values of startup wear (in mg) and those of steady running wear (in mg per hr). By integrating the curve in terms of radioactivity versus oil volume flowing around the scintillator, one can obtain relative values of these data; for example, values corresponding to wear debris dispersed in the whole oil change.

Iron Balance — However, the amount of wear particles dispersed in the oil does not represent the actual total wear, but only a fraction called "apparent wear," and a systematic study has revealed that a certain amount of wear debris is embedded

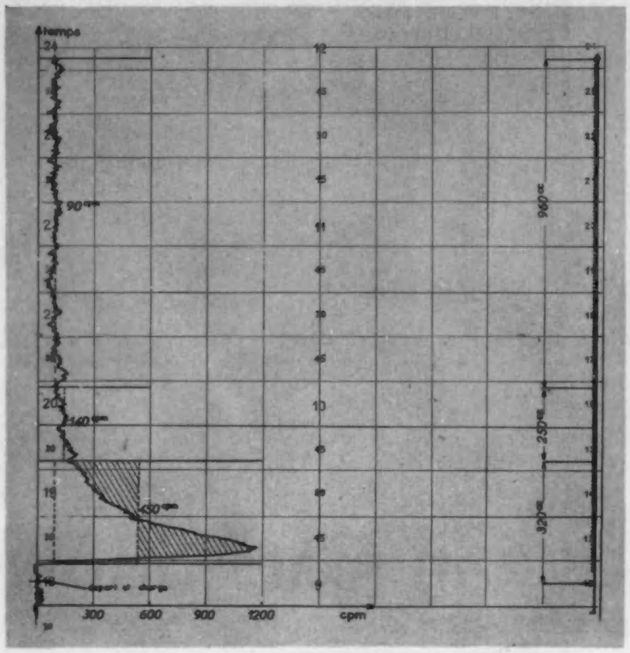


Fig. 1 — Constant wear rate is represented by this vertically recorded curve.

in piston grooves and upon ring faces, in lacquer and varnish deposits, or escaping with combustion gases. This amount of wear particles not dispersed in the oil was assumed to vary with type of lubricant and hence special equipment and procedures were set up to determine the balance of iron from all sources in every possible way, that is:

Oil pumped from the gutters Oil flowing directly to the sump	Iron in the oil (apparent wear)
Wear debris stuck on ring faces Wear debris embedded in piston grooves Wear debris escaped to the exhaust system	Iron out of the oil

This total amount of iron, which represents actual wear, was compared to the ring weight decrease determined by weighing this ring, before and after each test. It has thus been established that the proportion of apparent wear in the actual total wear reaches about 82% for a straight oil and 74% for an additive oil.

This work confirms the accuracy and reproducibility of the test method.

Test Results

Some results obtained from test runs conducted using the new radiotracer techniques are summarized below:

Startup Wear — In frictional operating conditions (low sulfur content fuel) startup wear is increased with shut down period duration, decrease in oil viscosity, and increase in cylinder wall temperature.

It appears that any factor contributing to improvement of adhesion of the oil film upon the cylinder wall decreases frictional startup wear.

In the same manner, oiliness agents and V.I. improvers are effective in reducing frictional startup wear.

In corrosive operating conditions (high sulfur content fuel) startup wear is increased as the fuel sulfur content increases and with low cylinder wall temperatures.

Detergent-type additives appear to be most effective in reduction of corrosive startup wear, by means of their alkalinity and surface protection capacity.

Steady Running Wear — In frictional operating conditions wear rate is increased with high cylinder wall temperatures and with too low or too high viscosity, which are opposite effects from those concerning frictional startup wear.

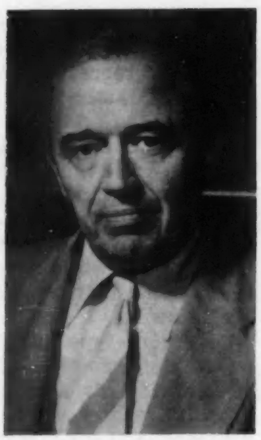
In corrosive operating conditions, as for startup wear, wear rate is increased with high sulfur content fuel and with low cylinder wall temperature.

Detergent-type additives may also reduce corrosive steady running wear, while additives generally known as antiwear agents appear most ineffective.

To Order Paper No. 66V . . .
. . . on which this article is based, turn to page 6.

ZIL, RUSSIA'S HIGHEST QUALITY CAR, has no price and is not sold to public. Its use is confined to top political and governmental figures and others in highest levels of authority. It is built in small numbers to government order.

Russian Cars Show No Startling Advances



by

Delmar G. Roos

Consulting Engineer

. . . who made this interpretive analysis at the request of the SAE Overseas Information Committee — for SAE Journal readers — of the FOUR Russian 1959 model cars that were displayed during the Soviet Exhibition at the New York Coliseum, June 30 to Aug. 10, 1959. (1958 models of two of these cars — the Volga and the Moskvich — have already been described by William Carroll in the August issue. Unlike the cars at the Russian exhibit, these earlier models had been imported privately and were available for close inspection and extensive testing.) The opinions expressed are those of author Roos.

THE four 1959 model cars shown at the Russian exhibit represent no startling advances over what we in America have today in styling, techniques of manufacturing practice, and engineering. In fact, the Russian automotive industry is behind us in some very important things. For example, they continue to use spiral bevels instead of hypoids in the Volga and Moskvich. I was told they expect to change very soon to hypoids in these models.

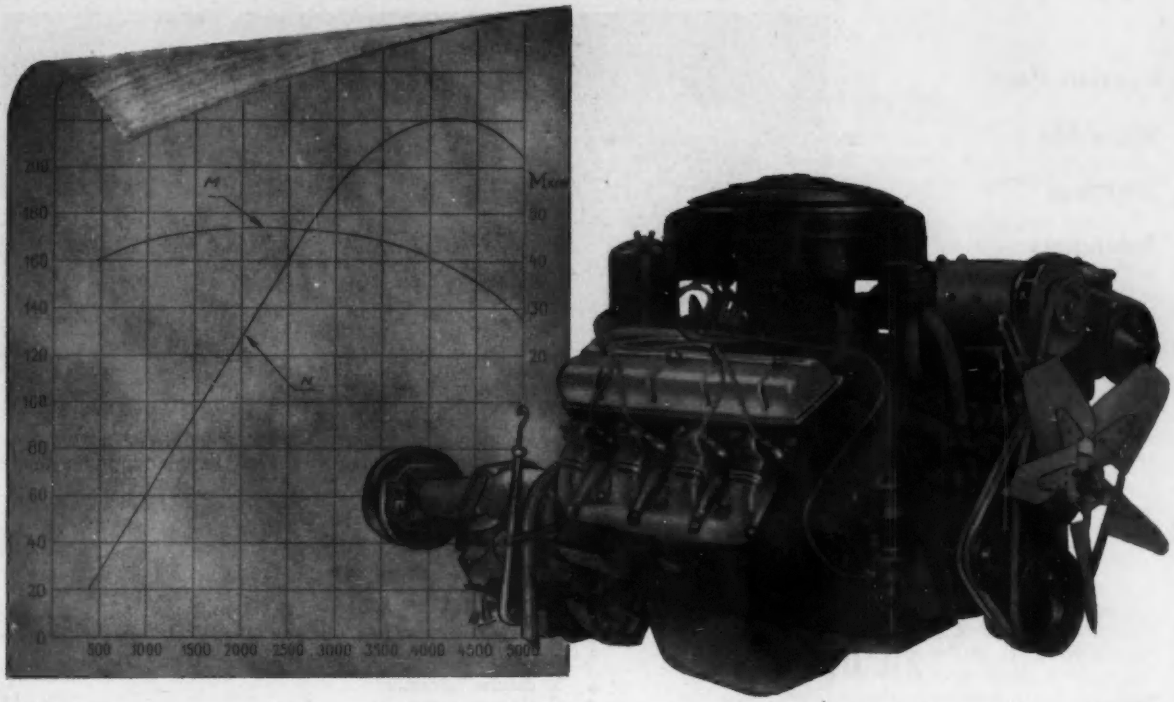
The body-cum-chassis construction seems heavy and unnecessarily clumsy as used on the Volga and Moskvich. One would think that, with so much similarity between the ZIL and the Chaika, a high degree of interchangeability could be resorted to between these two cars, both of which are in small volume of production, especially as regards engines — both V-8, with the same bore, transmission, and axles — but this is not so.

The styling of the cars is a mixture of "pre-fin" American with touches of the continental. There is a mixture of the conservative with attempts at innovation, mostly in the way of very complete equipment and elaborate instrument panels.

All cars have reasonably good baggage capacity. They all carry the spare tire vertically on the right side of the luggage compartment, except the Moskvich station wagon, which carries it under the floor.

They all have 12-v ignition systems, with vacuum and speed control of spark advance. They all use a single pair of sealed-beam headlights having double filaments for passing and driving.

They are all equipped with radio, two windshield wipers, two visors, cigar lighter, heaters, and ventilating systems.



ZIL V-8 ENGINE produces 220 hp at 4200 rpm. It has overhead valves, valve seat inserts in aluminum head. Cylinder block and crankcase are aluminum, with removable wet liners. Pistons are aluminum, tin plated. Displacement is 365 cu in., compression ratio 10.5/1.

Temperature control of cooling systems is, for all cars, by means of shutters in front of the radiator core — thermostatically operated on all but the Moskvich, which is hand controlled. The use of shutters was once in vogue in the U. S. A. but was found to be too expensive, was a source of rattles and whistling noises at certain speeds, and the shutters often stuck.

Great care was given in all the bodies shown to sealing against water, dust, and undesired air leaks.

The attempt to use unit body construction in the Volga and Moskvich resulted in a hybrid construction that seems to have the advantage of neither the separate frame or body-cum-chassis construction.

Trim and interior finish were plain and in good taste both as to colors, style of trim, and selection of material. Again the keynote was to be conservative and not gaudy.

Nothing new or startling was revealed in body stamping design or method of body stamping assembly. It was noted, however, that the outer edges of all door panels except those of the Moskvich were flanged over the inner door panels, as is standard practice. On the Moskvich they are merely turned in at right angles to the outer panel to match the corresponding flanges on the inner panels, which are turned in to face the outer flanges in which they nest and to which they are spot welded.

Russian practice seems to favor tempered safety glass as against the laminated type. This may not be true of all models, as for example the ZIL. There are so many inconsistencies that it is not safe to draw the conclusion that, because certain practices are used in one model, they will be used in all.

The gas filler spout in the Moskvich is in the center of the luggage compartment back panel, under the license plate. The rear deck lid is locked from inside the car. When lifted the license plate uncovers the spout. No mention is made of this construction being used on the other cars, nor is it stated where the filler spouts are located.

All engines are stated to have aluminum heads and blocks with sleeve inserts in the blocks. The Moskvich, however, appears from the description to have an iron head and block also, with sleeve inserts.

All con rod big end and main bearing liners are of the steel-backed bimetal shell type.

All cars use 14-mm spark plugs, except the Volga, which uses 18-mm plugs — reason for this exception not given.

All wheel brakes are two shoe with adjustable, fixed anchor pins, except on the Moskvich, which has a floating anchor pin for the two shoes.

Inconsistencies of this sort appear many times throughout their specifications.

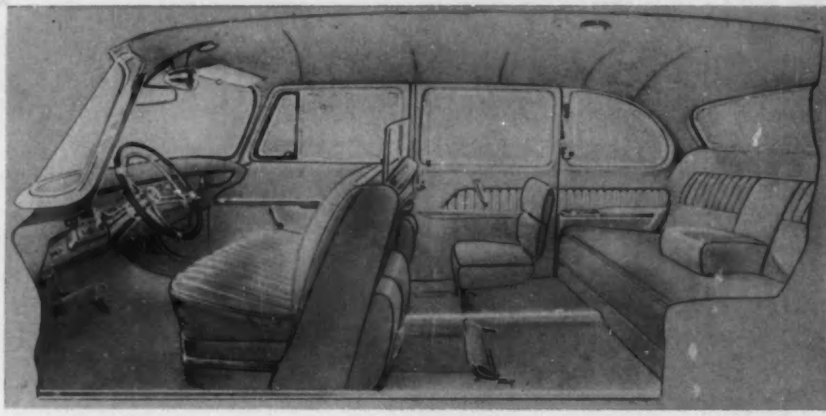
Detailed specifications . . .

. . . as far as I could get them from the Russian car catalogs and corrected in part through the courtesy of D. Lialin of the Moscow Automobile Works . . .

. . . are given on the following pages.

Russian Cars Show No Startling Advances

... continued



INTERIOR OF ZIL features roominess and comfort. It accommodates eight passengers, having folding seats for two in rear compartment. Note wraparound windshield and large rear window.

Specification Details for Russian Cars

ZIL III

Engine:

V-8

Overhead valves, valve seat inserts in aluminum head. Push-rod valve gear

Cylinder block and crankcase are aluminum with removable wet liners. Combustion chambers are wedge shaped, machine finished. Pistons are of aluminum, tin plated

Bore 100 mm (3.94 in.), stroke 95 mm (3.74 in.), displacement 5.98 litres (365 cu in.), compression ratio 10.5/1, 220 hp (max) at 4200 rpm, torque 340 ft-lb at 2250 rpm

Lubrication system, pressure feed with throw-off from con rod clearance to cylinder walls. Has two-stage oil filter with oil cooler

Crankshaft, number of bearings not stated. Probably hardened chain bearings and pins, which appears to be general practice in Russia

Camshaft drive not stated

Air Cleaner:

Oil bath with intake silencer

Fuel System:

Down-draft four-barrel carburetor with automatic choke

Fuel pump: diaphragm type driven off camshaft with a push-rod (illustration in catalog is stated to be out of date)

Fuel:

89 octane minimum

Cooling system:

Closed system with pressure release cap. Pressure setting not stated. Centrifugal circulating pump with five-blade fan mounted on pump shaft. Fan blades tapered toward the tips, wide at hub (reason not explained and practice not followed on other Russian cars)

Radiator temperature control is by a row of vertical 1-in. wide shutters in front of the radiator core and fan, controlled by a thermostat

Exhaust System:

Separate exhaust manifold pipes and mufflers for each block of four cylinders. One large muffler ahead of a smaller muffler for each of the two exhaust lines

Transmission:

Four-element torque converter with a stall torque conversion ratio of 2.6/1 driving through a gearbox with two forward speeds and reverse. Gearbox speeds 1.72/1 and 1/1. Reverse 2.39/1

With control button on dash the driver can overrule the gearbox's choice of ratio, which is modulated by speed and torque (stated by Soviet engineers to resemble Chrysler system on Imperial)

Propeller Shaft:

Made in two sections with intermediate bearing flexibly

Some Engine and Car Performance Figures for the Four Russian 1959 Model Cars Exhibited

	Horsepower	Torque, ft-lb	Displacement, cu in.	Max Hp per Cu In.	Max Torque per Cu In.	Average Fuel Consumption, mpg	Max Speed, mph	Fuel Octane Requirement
ZIL	220	340	365	0.604	0.93	12.4	105	89
Chaika	195	296	336	0.570	0.88	15.7	100	92
Volga	80	130	149	0.530	0.87	26	84	80
Moskvich	45	65	83	0.540	0.78	36	65	72

Note: It is interesting to note that the octane requirement for the engine is reduced for the smaller engines and cheaper, lighter cars, hence the performance per cubic inch is reduced and is low compared to latest American and European figures.

Procurable data failed to state whether engine output figures are based on net with all accessories or on the bare engine . . . . nor are the conditions, under which fuel consumption figures were obtained, given.

mounted. Universals of conventional, needle bearing cross type

Electrical System:

12-v, 68-amp-hr battery. 500-w generator of commutating type. 14-mm spark plugs

Electric windshield wipers with vacuum-operated washer. Electrically operated door glasses and glass partition

Single sealed-beam headlights, two filaments. Front side and front parking and marker lights, two sub-bumper front road lights, two red taillights, yellow lights for twin signal and white lights for backing up. License light. Interior lights

Electrically adjusted front seats

Radio controlled by both front compartment and rear compartment panels. Electrically raised and lowered antenna

Ignition:

Battery distributor type with vacuum and speed control

Front Suspension:

Independent coil spring and wishbone type (similar to Packard 1942 model). Lower wishbone has a long arm extending toward rear and anchored in a rubber-lined ball and socket joint. Shock absorbers are of the lever type, double acting. The shock absorber lever constitutes the upper link of the system. Torsion bar stabilizer

Rear Suspension:

Axle type with long semi-elliptic spring encased in leather spring covers. Telescopic-type shock absorbers. Type of shackle not disclosed

Rear Axle:

Stamped steel banjo type with cast gear carrier of steel or malleable iron. Hypoid gears, 3.54/1 ratio. Semi-floating axle shafts

Steering:

Power-assisted worm and nut with recirculating balls (U.S. Saginaw-type construction). Overall ratio 22.4/1

Brakes, Foot:

Drum-type, two-shoe hydraulic with vacuum booster. Adjustable, fixed anchor pins for shoes

Brake, Hand:

Drum type with two expanding shoes mechanically operated, mounted back of the transmission on drive shaft

Wheels:

Pressed steel, disc, ventilated drop-center rims

Tires:

8.90 × 15 low-pressure tubeless

Frame:

Riveted and welded and number of cross-members. Closed box section side members

Body:

Four-door stamped-steel limousine, seats for eight, three in front (59.5 in. wide), three in rear (55 in. wide), two on folding seats in rear compartment. Wraparound windshield, tempered safety glass. Front seat leather covered. Rotating-type door locks. Wedge-type anti-rattle dovetails in doors. Key locks on left front and right front door

Principal Dimensions:

Overall length 242 in., overall width 80 in., overall height 64.5 in., wheelbase 148 in., tread, front 61.5 in., tread, rear 65 in., ground clearance (under engine) 7.6 in.

Performance:

Top speed 105 mph

Fuel consumption (cruising) 12.4 mpg

Capacities:

Fuel tank 21.1 gal, cooling system 7.1 gal, lube system — not stated, transmission — not stated, rear axle — not stated

Dry Weight:

Not stated

Chassis Lubrication:

The specifications describe a centralized pressure lubrication system for the articulated points of the front suspension and steering connection. No such system is mentioned in connection with the other three cars exhibited

Chaika (Gull)

Engine:

V-8

Overhead valves, push-rod operated

Cylinder block, crankcase, and cylinder head are aluminum, also the pistons, which are tin plated. Valve seat inserts are used in the cylinder head. Combustion chambers are wedge shaped, machine finished. Pistons are of aluminum tin plated

Bore 100 mm (3.94 in.), stroke 88 mm (3.46 in.), displacement 5.5 litres (336 cu in.), compression ratio (not stated) probably 10/1, 195 hp at 4400 rpm, torque 296 ft-lb, speed not given

Lubrication system, pressure feed with throw-off from con-rod clearance to cylinder walls. No mention of details of oil filter system but probably similar to ZIL

Crankshaft, number of bearings not stated. Mains and pins probably hardened by induction method, which

DELMAR G. (BARNEY) ROOS, a past-president of the SAE, is highly qualified to make this analysis of the four Russian cars exhibited at the New York Coliseum. He was vice-president of engineering and later executive vice-president of Willys-Overland, following many years as chief engineer and then vice-president of engineering at Studebaker. He also served as a consulting engineer for Rootes, Ltd., the well-known English car makers.

In gathering data for this article, Roos encountered a number of obstacles that made it extremely difficult for him to do a first-class technical reporting job. He relates, for example:

"The cars were mounted on turntables, ceaselessly rotating, giving the spectator . . . no chance whatever to study details closely or to sit in the cars.

"The car catalogs I was given were bad translations, lacking in many important details, rich in flowery description of visible details but sadly lacking in a description of important but invisible details of design and specifications.

"After repeated requests to see a qualified engineer I finally did meet one, who went over the specs with me, overcoming as best we could the language barrier . . . but they would not stop the cars so I could sit in them and pass judgment on interior treatment, trim, comfort, and workmanship.

"The specifications and descriptions are given herewith for these 1959 Soviet cars with the understanding that much is lacking in knowledge of detail design."

Russian Cars Show No Startling Advances

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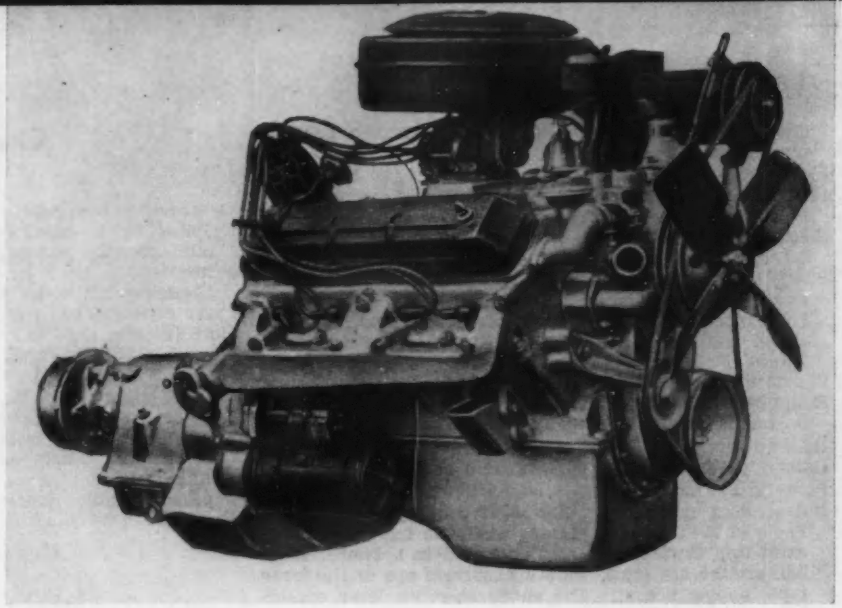


CHAIKA V-8 ENGINE produces 195 hp at 4400 rpm. Displacement is 336 cu in., compression ratio is probably 10/1.

CHAIKA also is not available to general public, and no price was obtainable. It is intended for industrial, technical, and scientific bigshots. Its maximum speed is 100 mph, and fuel consumption 15.7 mpg.

seems standard practice in all models

Camshaft drive not stated

Air Cleaner:

Oil bath and intake silencer

Fuel System:

Down-draft carburetor (number of barrels not stated, probably four), automatic choke. Fuel pump: diaphragm type operated by push-rod from camshaft

Fuel:

92 octane minimum (note this is as against 89 octane for ZIL) — pretty close limits for combustion-chamber design!

Cooling System:

Tube and fin radiator, four-blade fan with rectangular blades mounted on pump shaft, belt driven. Centrifugal pump

Temperature control by vertical shutters in front of radiator and fan whose position is controlled by thermostat

Exhaust System:

Separate exhaust manifolds for each block of four cylinders, separate exhaust systems to the tail pipes with large muffler preceding small muffler between exhaust and tail pipes. One odd feature mentioned but not seen is a balancing tube between the two separate systems

Transmission:

Hydraulic torque converter with planetary gears, giving three forward speeds and reverse, with button controls. Operation automatic except low speed is used only as an emergency low and remains in gear when corresponding button is depressed. Other speeds act on modulated control of torque and speed

Propeller Shaft:

Made in two sections with intermediate bearing in cushioned mounting. Universals of conventional needle bearing, sealed type

Electrical System:

12-v battery (capacity not given, but probably 68 amp-hr). 500-w generator of commutating type. 14-mm spark plugs

Electric window operation and windshield wipers, electric antenna control, radio. Two single twin-filament sealed-beam lamps in front, marker lights and bumper lights. Rear: two red taillights, two yellow turning signal lights, two backing lights, white. Direction signal, self-canceling type. Cigar lighter, interior lights

VOLGA IS A SMALLER ECONOMY CAR allegedly for the populace. It is less luxurious, seats five, and has a maximum speed of 84 mph.

LUGGAGE COMPARTMENT OF VOLGA is roomy, with spare tire placed vertically on right side.

Ignition:
Battery distributor with vacuum and centrifugal control

Front Suspension:
Independent coil springs, conventional upper and lower V links, telescopic shock absorbers

Rear Suspension:
Axle type with long semi-elliptic springs covered with leather spring covers, hydraulic shock absorbers of telescopic type

Rear Axle:
One-piece cast housing (this is hard to believe and may be a poor translation) with flanged axle shafts (¾-floating construction — probably the same type as that used in the ZIL). Hypoid gears, ratio not stated

Steering:
Gemmer type of gear, power assisted by cylinder outside of gear itself, controlled by drop lever arm

Brakes, Foot:
Drum type hydraulically operated, two shoes on all four wheels, with vacuum booster. Adjustable, fixed anchor pins for shoes

Brake, Hand:
On rear end of transmission, on drive shaft. Mechanically operated

Wheels:
Stamped steel, disc, not ventilated

Tires:
8.20 × 15 low-pressure tubeless

Frame:
Channel section pressed steed X frame construction

Body:
Stamped-steel construction, four-door sedan, seats in three rows, front can seat three, rear seats can seat three, casual seats folding in rear compartment can seat two. Wrap-around windshield, safety glass (tempered) all around. Hancock-type rotary doors locks on all doors with wedge-type dovetails for antirattle. Spare tire stored vertically in rear luggage compartment

Principal Dimensions:
Overall length 220 in., overall width 78.7 in., overall height 61.4 in., wheelbase 128 in., tread, front 60.6 in., tread, rear 60.4 in., ground clearance not stated.

Performance:
Top speed 100 mph
Fuel consumption 15.7 mgp

Capacities:
Fuel tank 21.1 gal, cooling system — not stated, lube system — not stated, transmission — not stated, rear axle — not stated

Dry Weight:
3960 lb

Volga

Engine:
4-cyl in line
Overhead valves, valves seat inserts in aluminum head. Push-rod valve gear
Cylinder block and crankcase unit are aluminum with removable wet liners. Combustion-chamber shape not described. Pistons are aluminum, tin plated, with two compression rings and one scraper ring
Bore 92 mm (3.62 in.), stroke 92 mm (3.62 in.), displacement 2.445 litres (149 cu in.), compression ratio 7.5/1
80 hp (max) at 4000 rpm, max torque 130 ft-lb
Lubrication system pressure feed with throw-off from conrod clearance to cylinder walls
Crankshaft, number of bearings not stated
Camshaft drive not stated

Air Cleaner:
Oil bath with intake silencer

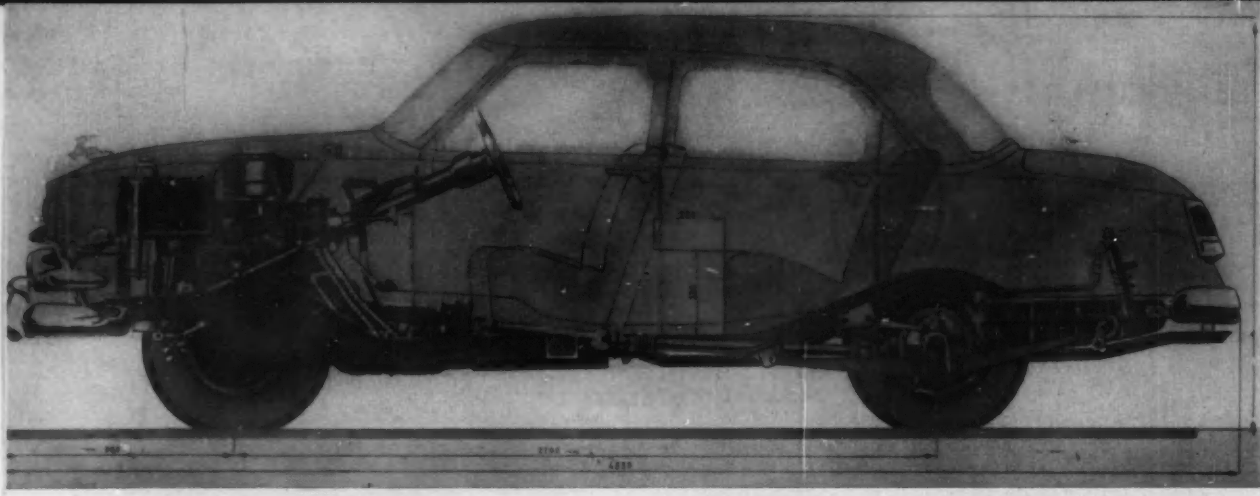
Fuel System:
Single-barrel down-draft with automatic choke
Fuel pump: diaphragm type driven off camshaft

Fuel:
80 octane minimum

Cooling System:
Fin and tube radiator. Four-blade fan mounted on water pump shaft, belt driven, single belt
Radiator temperature control by vertical shutters in front of radiator, controlled by thermostat

Exhaust System:
Exhaust manifold and pipe. Single tuned muffler and tail pipe

Transmission:
Torque converter with planetary gear and hand lever con-



PHANTOM VIEW OF VOLGA shows a chassis construction that seems heavy and unnecessarily clumsy.

Russian Cars Show No Startling Advances

. . . continued

trol on steering column. Action is automatic with ability to "override" with hand lever. Ratios: first 2.84/1, second 1.68/1, reverse 1.72/1. Stated to be similar to Fordomatic system

Propeller Shaft:
Made in two sections with intermediate bearing, cushion mounted. Universal joints of conventional needle type, cross sealed

Electrical System:
12-v, 54 amp-hr battery. 220-w generator. Voltage regulated and current regulated

Ignition, battery type, automatic speed and vacuum control, and octane selector. Three-position ignition key, neutral, on, start, returns to neutral

Two 7-in. sealed-beam headlights, two filaments. Two taillights: upper section acts as taillight, stop light, and turn indicator; lower section as backing light. Front under lights act as turn indicators. Dome lamp in body roof. Luggage compartment light with lid-operated switch

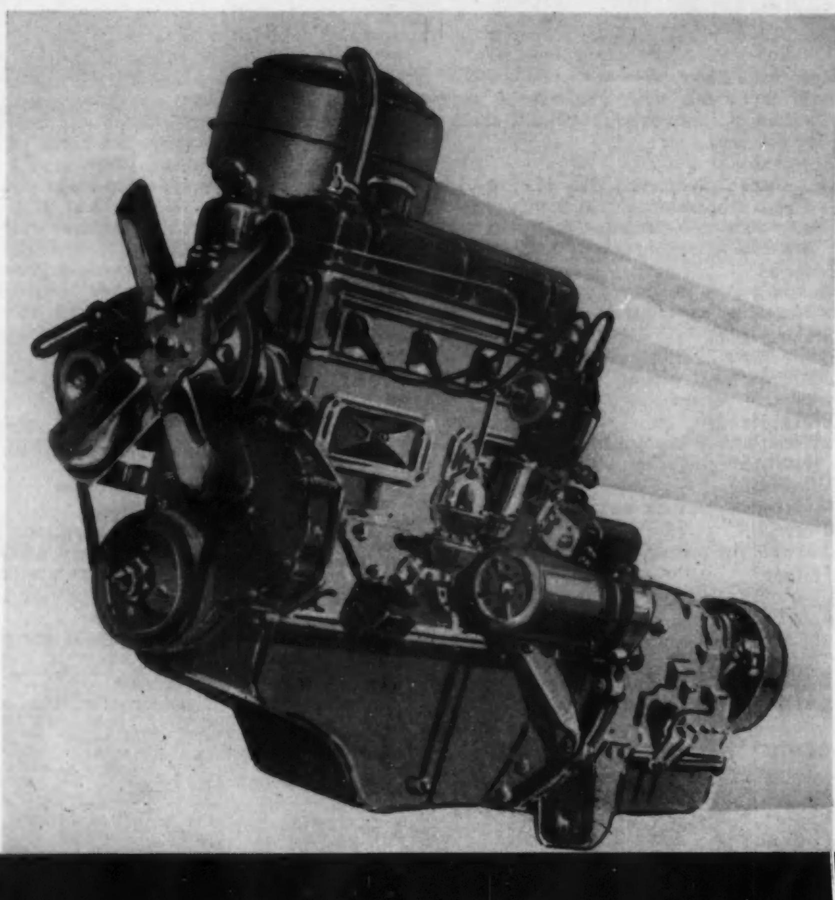
Ignition:
Battery distributor type with vacuum and speed control

Front Suspension:
Independent type with upper and lower V links, lever type double-acting shock absorber. Coil springs

Rear Suspension:
Axle type with semi-elliptic springs with leather covers. Spring eyes bushed in rubber (first mention in any specification of spring shackle structure and method of anchoring leaf springs)

Rear Axle:
This is stated to be a "cast housing and forged cover." This is a hopelessly incorrect translation. Examination as far as possible showed a trumpet-type axle, split in

VOLGA 4-CYL IN LINE ENGINE produces 80 hp at 4000 rpm. Displacement is 149 cu in., compression ratio 7.5/1.



an off-center position. It definitely is a spiral bevel, not a hypoid, and the ratio is given as 3.78/1

Steering:
Hour-glass worm and double roller follower (Gemmer type), ratio 18/1 (presumably in straight-ahead position)

Brakes, Foot:
Hydraulic, two-shoe, drum type on four wheels. Adjustable, fixed anchor pins for shoes

Brake, Hand:
Drum-type propeller shaft brake behind the transmission. Foot brake pedal is suspended type on bushing, requiring no lubrication

Wheels:
Stamped steel disc. Chrome-plated hub caps

Tires:
6.70 × 15 low-pressure (tubeless?)

Frame:
No description of frame is given, but it was verbally stated that the body is of unitized type up to the dash. From there forward a frame side rail and cross-member structure is fastened to the body underside, which is reinforced to take the stresses. The front fender aprons are also fastened in as structural members to produce what amounts to a combined body and frame unit.

Body:
Four-door sedan. Steel stampings. Curved windshield (not wraparound). Hand-operated windows. All glass safety, tempered. Body seats five. Back of front seats fold down to make a couch. Hancock-type rotary door

During his talks with Soviet representatives in charge of the Russian car exhibit, Roos obtained some information on those phases of Russian economic, social, and political structure that background Russia's automobile manufacturing industry and use of cars. Here are some of his comments, based on what he was able to elicit from Soviet officials at the exhibit:

"I was told that the total volume of trucks and passenger cars that will probably be built in Russia this year would be about 500,000, of which approximately 145,000 would be passenger cars. (Not a very large production of passenger cars when divided into four totally different models. Not much chance for automation and large volume production techniques.)

"I was informed that the Volga and Moskvich plants were equipped to turn out 2 to 2½ times present volume. (If true it still does not signify any large volume of cars ahead for either domestic or export production unless they are going to ram them down the throats of their satellites.)

"The discussion of prices and possible markets, however, poses some very interesting questions.

"The ZIL, I was told, had no price and is not sold to the public. Its use is confined to the top political and governmental figures, members of the Polit Bureau, ministers, premier and deputy premier, generals, heads of police, etc., in highest levels of authority. Note: It is the fastest car, most luxurious, biggest, with separation between driver and passengers by glass division and means of communication between them, the most complete radio, and luxurious and complete appointments. The car represents their most advanced design and replaces the ZIS. It is, of course, built in small numbers to government order at a special plant.

"The Chaika is new and, I was told, not available to the general public. No price was obtainable. It is intended to be used by such people as: plant managers, heads of research sections in all branches of science and medicine, managers of public utilities, and, in general, non-governmental bigshots. Ownership, if ownership is possible, is determined by level or status in the economic, educational, or industrial setup.

"The Volga (which replaces the Pobieda) is allegedly a car for the populace. Price quoted to me f.o.b. Russia was 40,000 rubles ($4000 at the tourist rate of 10 to the dollar or $10,000 at the nominal international rate of four rubles to the dollar). A smaller economy car, it is less luxurious, seats five, and has moderate speed. 'Who can buy it?' I asked. 'Anyone who has the money,' was the answer, which leaves one still in the dark. 'It will be used by lesser officials and lower echelons of responsibility in government and business,' I was told.

"The Moskvich is the smallest car and is strictly in the small European four-passenger sedan class (such as the Hillman and the Morris 1½ litre). Price was quoted as 25,000 rubles ($2500 at the tourist rate, $6250 at the official rate). Who can buy it? Anybody with the money. One is inclined to ask, 'Who has the money?'

"Russian cars (Volga and Moskvich) cannot be bought in the United States because we have no trade agreement with Russia. I doubt if any could be sold, anyway, at the prices quoted and the uncertainties of obtaining service and spare parts.

"Probably no single symbol could be selected from our everyday life more typical of our democracy and freedom than the automobile. Anyone in the U.S.A. can own one who can pay for it and obtain a driving license. He can go *where* he wants, *when* he wants to, by *what route* he *wants*, and change his plans if he wants to.

"In Russia the government wants to know where every individual is at all times. One can picture the problem that the untrammeled use of the motor car would create.

"It is interesting to notice that the performance capacities of their cars are graded downward to accord with the political, economic, and technical levels of those allowed to use them.

"Consider that all transportation in Russia is government controlled, railroads, streetcars, buses, and canals. Is it likely that the Russian government — at this stage of its economic struggle — wants to encourage competition with itself?

"One of the most astonishing statements made to me about motoring in Russia was that there is *no speed limit in the cities* for motor cars. I repeated and questioned this statement, to be sure that I understood. "The speed is up to the driver," was the reply. Necessarily, this means that there is very little traffic in the cities. Since practically all cars are officially operated, this must make for a very exciting spectacle and certainly indicates that at present, at least, wide use of the motor car and dense traffic conditions are not expected in the near future.

"The absence of a great fleet of privately owned passenger cars in Russia, with its enormous distances and widely separated industrial centers (I assume that such good roads as there are are mostly in and around the big cities), points out a weakness in its present transportation facilities, lack of capacity and lack of flexibility, and for the present almost complete dependence on railway, river, and air transport."

ACCESS TO LUGGAGE COMPARTMENT OF MOSKVICH station wagon is through this rear door. Spare wheel is horizontally placed under luggage compartment floor. Tool box is next to spare wheel.

Russian Cars Show No Startling Advances

. . . continued

locks on all doors between wedge. Antirattle dovetails

Principal Dimensions:
Overall length 190 in., overall width 71 in., overall height 64 in., wheelbase 106 in., tread, front 55.5 in., tread, rear 55.9 in., ground clearance (under engine) 7.47 in.

Performance:
Top speed 84 mph
Fuel consumption 26 mpg

Capacities:
Fuel tank 16 gal, cooling system — not stated, lube system — not stated, transmission — not stated, rear axle — not stated

Dry Weight:
2990 lb

Moskvich (Muscovite)

Engine:
4-cyl in line
Overhead valves, push-rod valve gear. In this car it was uncertain whether it had aluminum head and valve inserts or cast-iron head. The cylinder block has sleeve inserts and it therefore seems strange that an exception is made from the practice in the other Russian cars of using aluminum block and head, but this point was not clarified. Combustion-chamber shape was not described but as compression ratio is only 7/1, it is assumed that it is fairly conventional. Pistons are tin-plated aluminum with two chrome-plated compression rings and one scraper ring
Bore 76 mm (2.99 in.), stroke 75 mm (2.95 in.), displacement 1.36 litres (83 cu in.), 45 hp (max) at 4500 rpm, max torque 65 ft-lb at 2600 rpm
Lubrication system, pressure feed with throw-off from rod big ends
Camshaft drive not stated

Air Cleaner:
Oil bath with intake silencer

Fuel System:
Single down-draft, but with *hand choke*
Diaphragm fuel pump

Fuel:
72 octane minimum

Cooling System:
Fin and tube radiator, four-blade fan on centrifugal circulation, pump shaft with triangular belt drive. *Hand controlled* vertical shutters in front of radiator core to control temperature

Exhaust System:
Cast-iron exhaust, exhaust pipe, tuned single muffler and tail pipe

Transmission:
Three speeds forward, plus reverse, synchronized on second and direct. Shift lever on steering column. Am advised that this transmission will immediately be replaced by a four-speed forward, plus reverse, gearbox synchronized on all four forward speeds. Present ratios on three-speed box are: direct 1/1, second 1.74/1, first 3.53/1, reverse 4.61/1

Propeller Shaft:
One section with needle bearings on crosspins, sealed

Electrical System:
12-v, 42-amp-hr battery. Voltage and current regulated generator. Ignition distributor is vacuum and speed controlled for spark advance
7-in. double-filament sealed-beam pair of single headlights, pair of front parking lights, usual rear combined taillights, turning signal lights and backing lights, license lights, dome and dash lights
Radio with dash control panel

Front Suspension:
Coil springs with upper and lower V-type links. Ball and socket type steering knuckle with no kingpin, similar to Ford type. Hydraulic shock absorbers, double-acting telescope type

Rear Suspension:
Axle type. Semi-elliptic uncovered leaf springs. Double-acting telescopic shock absorbers. Type of spring and bushings not stated (probably similar to Volga), rubber bushed

Rear Axle:
Welded pressed housing (probably banjo type with carrier). Final drive spiral bevel ratio 4.71/1

Steering Gear:
Hourglass-type worm with double-roller follower on steering cross-shaft (Gemmer type) *not* power assisted

Brakes, Foot:
Hydraulically operated drum type on all four wheels. Two-shoe, *self-centering anchor pins*

Brake, Hand:
Expanding shoe type, mechanically operated on rear wheels (same shoes as those hydraulically operated by foot

Wheels:
Pressed steel disc type

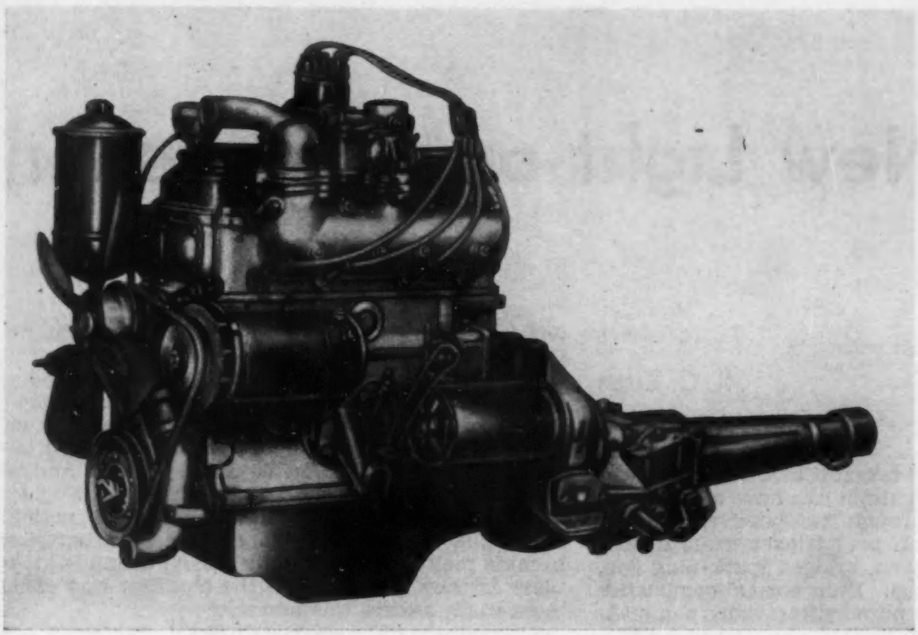
Tires:
5.60 × 15 low-pressure tubeless

Frame:
Semi-unitized construction like Volga, that is, a unit body and frame up to the dash. Forward of that a strong side member and front cross-member structure, permanently welded and bolted to the body under-structure, fender apron stampings functioning as structural reinforcements

Body:
Four-door sedan. Curved-glass windshield. All windows of tempered glass, hand operated. Hancock-type rotary door locks with wedge dovetails for antirattle and lock keeper registration. The front seats, like the Volga's, can be tilted back to a horizontal position to form a bed

Station wagon has body extension to roof to give added rear quarter window and fill length of available storage space. A rear fifth door is provided, with lock and hinges, to swing to the left. Tire is flat under the rear floor. The rear seat can be swung down to rear loading floor level to make available all the space behind the front seat for loading.

	Sedan	Station Wagon
Principal Dimensions:		
Overall Length, in.	160	160
Overall Width, in.	60.6	60.6
Overall Height, in.	61.5	63
Wheelbase, in.	93.2	93.2
Tread, Front, in.	48	48
Tread, Rear, in.	48	48
Ground Clearance, in.	7.9	7.5
Performance:		
Top Speed, mph	71	65
Fuel Consumption, mpg	36	31.4
Capacities:		
Gasoline Tank, gal	9.1	9.1
Cooling System and Heater, gal	1.99	1.99
Engine Lubrication, gal	1.14	1.14
Transmission Case, qt	0.74	0.74
Rear Axle Housing, qt	1.45	1.45
Dry Weight, lb	2183	2270



MOSKVICH 4-CYL IN LINE ENGINE produces 45 hp at 4500 rpm. Displacement is 83 cu in., compression ratio 7/1.

STATION WAGON VERSION OF MOSKVICH, Russia's smallest car, has five doors, an all-metal body, and can carry four persons plus 220 lb. If rear seat is folded down, it can accommodate two persons plus 550 lb.

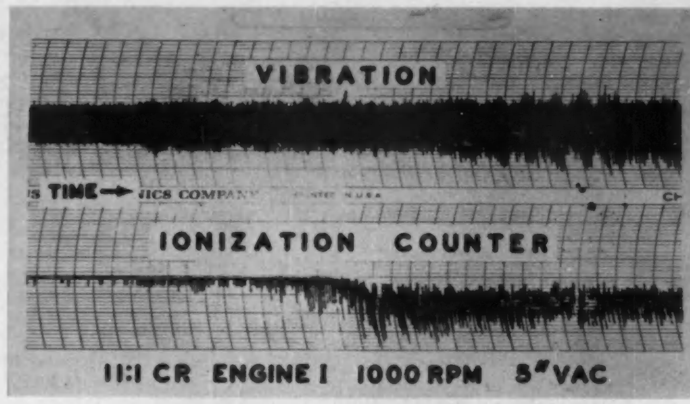


Fig. 1 — Multicylinder misfiring roughness from migrating deposits. Oscillograph record of vibration and ion gap signals.

New Light on Combustion

Based on paper by

R. C. Tupa

Standard Oil Co. (Ohio)

LABORATORY studies reveal that inaudible as well as audible surface ignition can have a detectable effect on vibration through increased combustion rates. Surface ignition may trigger gross deposit migration, which, in turn, bridges spark-plug gaps to cause severe vibration. Even normal combustion rates of widely varying pure hydrocarbons can make the difference between smooth and harsh combustion in higher compression engines.

There were several occasions where laboratory engines exhibited severe roughness when building up and stabilizing deposits on nonadditive base fuels. This roughness had all the earmarks of a badly misfiring engine. Violent vibrations were accompanied by 10–20% load losses. The roughness occurred at loads as light as 17 in. Hg vacuum (1000 and 1500 rpm) with no unusual engine noises preceding.

After shutdown of the engine in the midst of severe roughness, the cause was found to be plug fouling, but due to shortening of the gap by gross deposit migration rather than the conventional shunt-resistance-type fouling at very high temperatures.

Cause of deposit transfer

It is not certain what triggers this gross transfer of deposits, but the oscillograph record of vibration and ion gap signals in Fig. 1 suggests a possibility. Surface ignition activity increased with time until about half-way across the record, the ion gaps became shorted and engine vibration increased greatly due to one or more fouled plugs. In this particular case, surface-ignition-induced knock developed before fouling. It is possible that thermal and/or physical stressing of light-duty deposits can cause large-scale deposit migration far beyond normal scavenging rates. Very likely, the deposit particles became molten (indicated by glossy, beadlike globules) as they flew about in the chamber and could more easily adhere to a surface.

An example of severe roughness during rumble is shown in Fig. 2. Here an engine with 11.3/1 compression ratio was operated on leaded benzene with light harshness. Both surface-ignition activity and noise increased with time until misfiring suddenly set in. The engine was untouched and the misfiring lasted for 45 sec before it cleared up.

The effect of additives has not been established, but they should be beneficial in so far as they make deposits less prone to surface ignition. This type of fouling is elusive to identify because of its random nature.

Harshness with normal combustion

Investigation also revealed that the magnitude of roughness resulting from operating a clean engine on hydrocarbons with normal high rates of burning is similar to effects of surface-ignition-induced roughness.

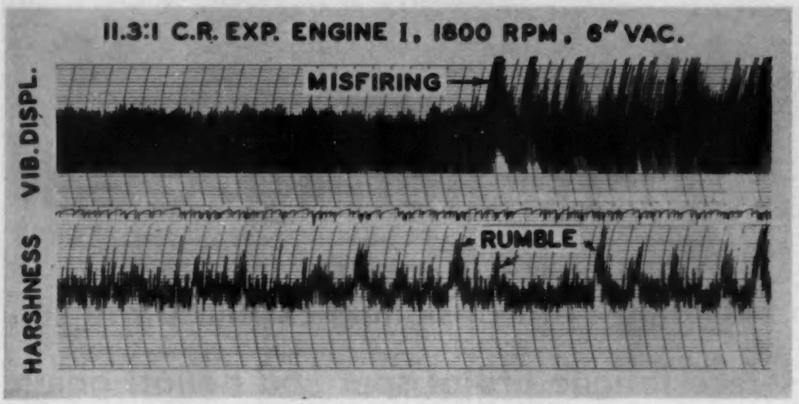


Fig. 2 — Severe roughness associated with rumble when a 11.3/1 compression ratio engine was operated on leaded benzene.

Noise and Vibration

Pressure data were obtained in No. 1 cylinder on clear isooctane, toluene, and benzene. Typical maximum rates of pressure were determined at several loads, 1800 rpm. Fig. 3 shows that at 15 in. Hg manifold vacuum, all three hydrocarbons behaved alike. As engine severity increased with load, the two aromatic hydrocarbons showed nearly double the rates of rise for isooctane at 9 and 4 in. of vacuum. As the *dp/dt* approached 30 psi per crank angle degree, light to moderate harshness was quite evident.

Harshness and roughness comparisons were next made on isooctane, toluene, and benzene, all leaded to 3 cc per gal. Operation lasted for one hour and during this time no audible or other indications of detonation or surface ignition were evident. Oscillograph records for the three fuels run at wide-open throttle show no ion gap signals. Subjectively, isooctane was judged to give smooth performance without obvious harshness. Toluene and benzene exhibited light harshness and concurrent increases in roughness. The relative hydrocarbon effects are directly comparable to those obtained in rumble work except for absolute magnitudes being about half what they were with deposits. The lack of spurious peaks in the records lends support to the idea that these differences in levels of harshness and roughness were due to normal combustion differences.

The fact that significant engine harshness and roughness could be obtained with aromatic hydrocarbons lends credence to earlier observations that the margin between normal combustion and so-called abnormal manifestations is becoming quite narrow.

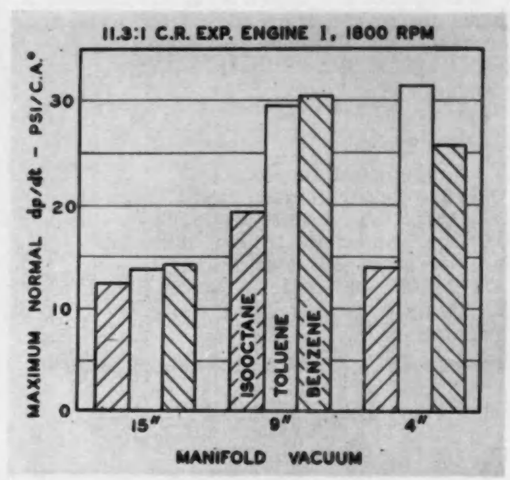


Fig. 3 — Fuel effects on maximum *dp/dt*. Here, clear isooctane, toluene, and benzene were run with clean combustion chambers. Pressure pickup was mounted in No. 1 cylinder.

To Order Paper No. 78W ...
... on which this article is based, turn to page 6.

Predicting Gear

New transmission test data help designers calculate the surface fatigue life of spur and helical gears.

Based on paper by

G. E. Huffaker

New Process Gear Division, Chrysler Corp.

A COMMON failure of today's transmission gears is traceable to surface fatigue. This results in pitting or spalling of the tooth face. Design information on this type of failure inevitably leads to fatigue curves similar to those used in the antifriction bearing industry.

Need for this information resulted from better design and production techniques at the root of gear teeth. Full fillet radii and shotpeening the fillet root during manufacture has virtually eliminated the once typical bending stress failures of teeth. The life of the gears now depends on surface fatigue.

The basic design equations come from work done by Heinrich Hertz and may be expressed as:

$$S_c = 0.59\sqrt{\frac{TE}{f\cos\phi}\left(\frac{1}{D_1\sin\phi}+\frac{1}{D_2\sin\phi}\right)}$$

for spur gears where:

T = Tangential force, lb
f = Face contact width of gear tooth, in.
ϕ = Operating pressure angle, deg
D_1 = Operating diameter of pinion, in.
D_2 = Operating diameter of gear, in.
E = Modulus of elasticity (30,000,000)
S_c = Compressive stress at center of contact area, psi

The corresponding equation for helical gears is:

$$S_c = 0.59\cos\psi\sqrt{\frac{6\times10^7T}{f\sin^2\phi_n}\left(\frac{1}{D_1}+\frac{1}{D_2}\right)}$$

where:

ϕ_n = Operating pressure angle in normal plane
ψ = Helix angle at operating pitch diameter

In both equations, the basic assumption is that the gear teeth approximate two rollers in contact, as shown in Fig. 1. Also, the analysis does not account for speed of the gears. However, if experimental data are taken in the desired speed range, the results have a built-in speed factor.

Finding Gear Life Data

Basic gear life data must be found experimentally, then the equations can be used to predict results of new designs. To produce these basic data, dynamometer tests were run on actual transmissions varying in input torque ratings from 200 to 375 lb-ft. Gear failures were plotted on log-log graph paper, as shown in Fig. 2. All gear stress repetitions are calculated and plotted for the driving gear members. Tests show this to be the critical pitting case even though the driven gear may have more gear tooth stress repetitions.

To make a usable curve, the raw data in Fig. 2 are converted to a line in Fig. 3. This is a base line above which 80% of the gears tested had longer life and below which 20% of the gears had a shorter life. This technique is similar to the one used by bearing manufacturers in reporting bearing life.

Example Using Equation and Curve

To demonstrate the use of the equation and curve, the following example shows how to predict the surface fatigue life of a gear set:

A truck transmission has a 21-tooth input drive gear mating with a 46-tooth countershaft driven gear. The second-speed gear set consists of a 20-tooth countershaft gear and a 37-tooth mainshaft driven gear. The transmission will be operated at 300 lb-ft input torque at 2200 rpm input shaft speed. Find the expected dynamometer life of the second-speed gear set.

ψ = Helix angle at operating diameter = 33.5 deg
D_1 = Operating diameter of 20-tooth countershaft gear = 3.3333
D_2 = Operating diameter of 37-tooth mainshaft gear = 6.1666
ϕ_n = Normal operating pressure angle = 16.884 deg
f = Face contact of mating gears = 0.940
T = Tangential force (plane rotation), lb

$$T = \frac{\text{torque input}\times12\times\text{gear ratio driving gear set}}{\text{radius of countershaft driving gear}}$$

$$= \frac{300\times12}{1.6666}\times\frac{46}{21} = 4732\text{ lb}$$

$$S_c = 0.59\cos\psi\sqrt{\frac{6\times10^7T}{f\sin^2\phi_n}\frac{1}{D_1}+\frac{1}{D_2}}$$

$$S_c = 0.59\times.8339\sqrt{\frac{6\times10^7\times4732}{0.940\times0.5558}\left(\frac{1}{3.3333}+\frac{1}{6.1666}\right)}$$

$$= 246{,}576\text{ psi}$$

Pit Point

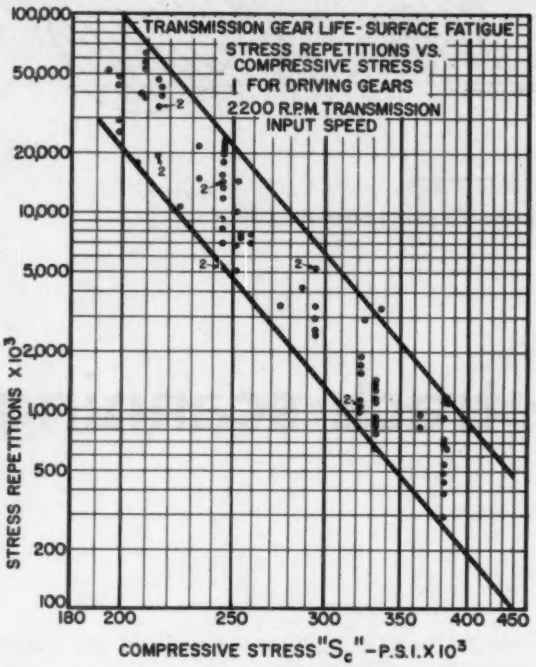


Fig. 2 — Surface fatigue failures in transmission gear teeth follow the same pattern as comparable roller-bearing tests.

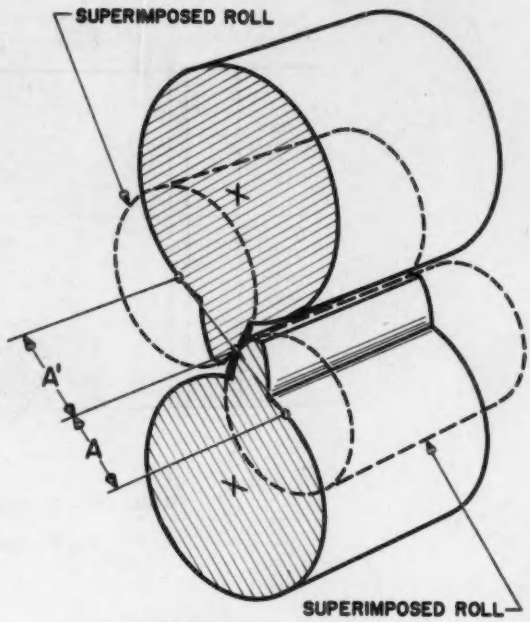


Fig. 1 — Surface fatigue theory developed for two elastic rollers in contact can be used to calculate stress levels in spur and helical gear teeth.

Entering curve Fig. 3 with this compressive stress value, the stress repetition or tooth contacts of the 20-tooth countershaft gear = 7,300,000.

As each gear tooth is stressed once per revolution, the hours expected life may be obtained as follows:

Countershaft rpm $= 2200 \times \frac{21}{46} = 1004$ rpm or stress repetition per minute.

$$\text{Life hours} = \frac{\text{stress repetitions}}{\text{stress repetitions per minute} \times 60}$$

$$= \frac{7,300,000}{1004 \times 60} = 121 \text{ hr}$$

To Order Paper No. 76T . . .
. . . on which this article is based, turn to page 6.

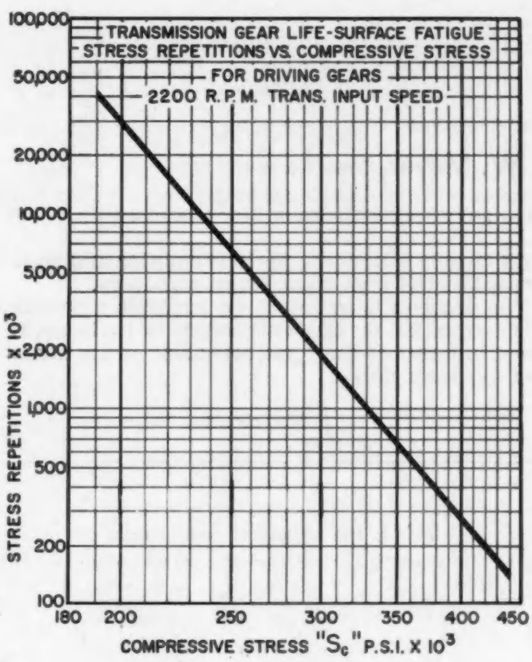


Fig. 3 — Data from Fig. 2 can be condensed to a single line by calculating the points of 20% failures. By using this line in design, of stress repetitions. Other percentage lines can also be calculated. 80% of gears produced will not have failed at the indicated number

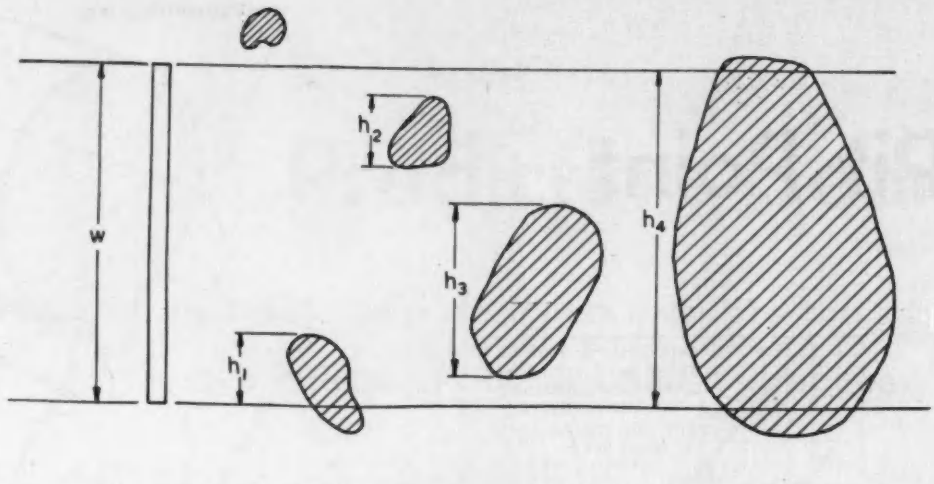


Fig. 1 — Particles intercepted in plane scanned with a slit.

Wide track scanning

Based on report by

E. W. Meyer, Casella Electronics Ltd.

(Presented before the Contamination Control Panel of the SAE Aircraft and Missile Hydraulic and Pneumatic Systems and Equipment Committee)

THE Casella automatic particle counter and sizer is based on the wide track scanning theory.

The problem is to obtain an accurate assessment of the equation for size distribution of particles. It is given in terms of their projected size and is denoted by $f(x)$ such that

$$\int_a^b f(x)\,dx = 1 \qquad (1)$$

> **This is the second of two articles** on automatically measuring contamination. "Ultrasonic Fluid Inspection Is Ultrafast," by Warren Strittmatter and Charles Albertson, Grumman Aircraft Engineering Corp., appeared last month.

where the limits a and b are the smallest and largest particles respectively.

In the wide track scanning method the oversize distribution is most easily found which is proportional to $F(z)$ of particles greater than some specific size z, where

$$F(z) = \int_{z \le a}^{b} f(x)\,dx. \qquad (2)$$

For ease of explanation consider the particles opaque and distributed randomly in a plane. If the plane is scanned with a slit, particles will be intercepted as shown in Fig. 1.

Some will be smaller than the scanning track, others only partially within the scanning track and some completely across the scanning track. The width of the scanning track is determined by the slit width w . . . and h_1, h_2, h_3, and h_4 are the maximum intercepts as measured in respect to the width of the scanning slit w.

The number of intercepts per unit length of track of all sizes with projected area h exceeding z is:

$$\phi(w) = N(w - 2z + \bar{z}) \qquad (3)$$

N is the number of particles per unit of area greater than z; z is the sensitivity of the system; and $\bar{z}$ is the mean size of intercept greater than z. The

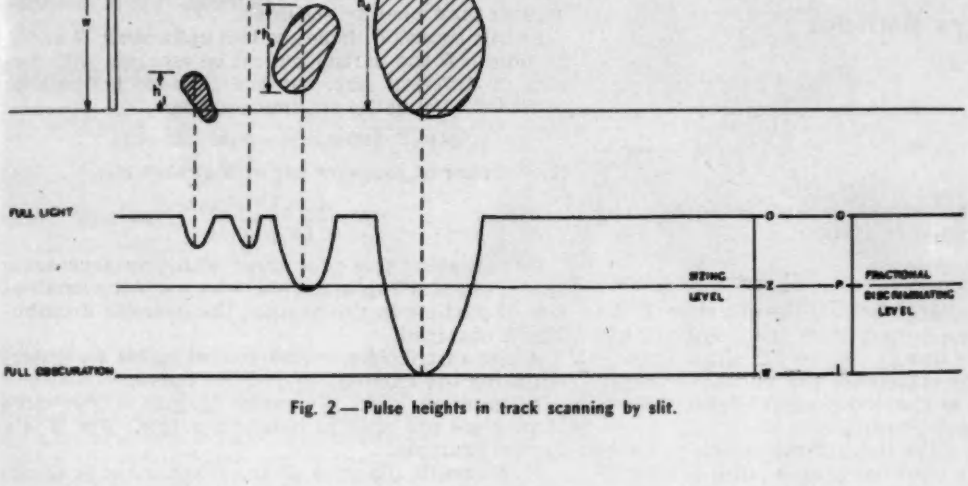


Fig. 2 — Pulse heights in track scanning by slit.

counts and sizes particles

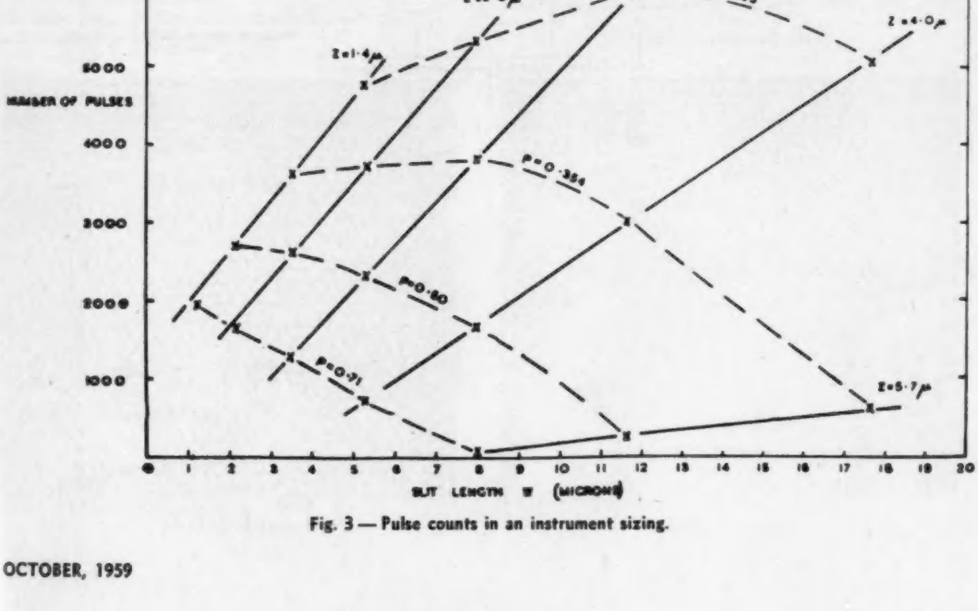
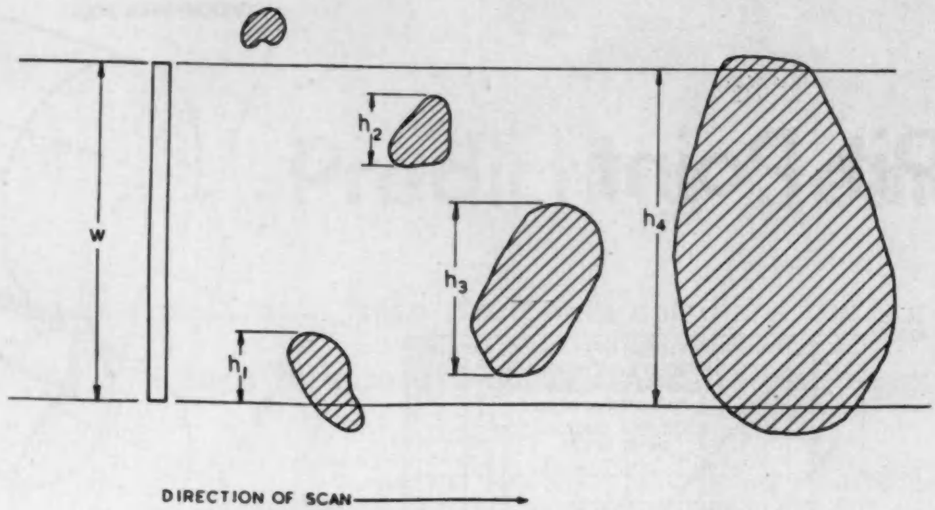


Fig. 3 — Pulse counts in an instrument sizing.



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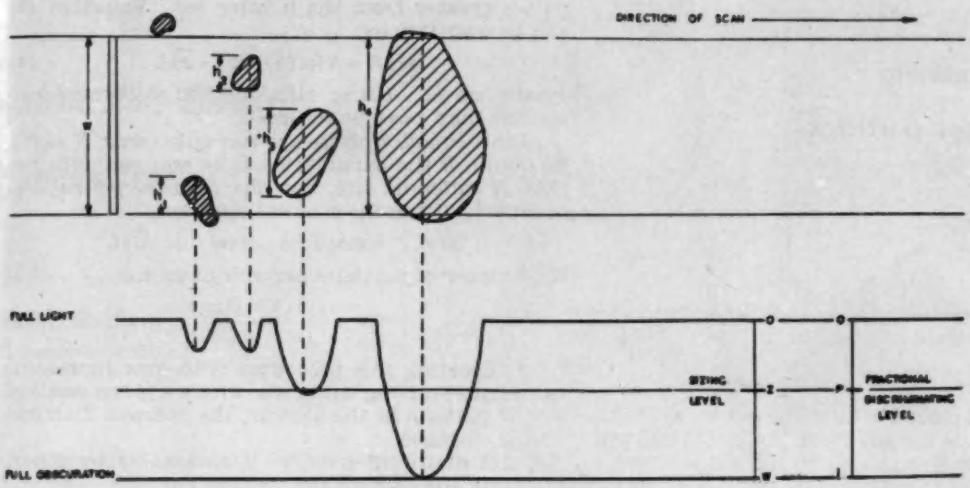


Fig. 2 — Pulse heights in track scanning by slit.

counts and sizes particles

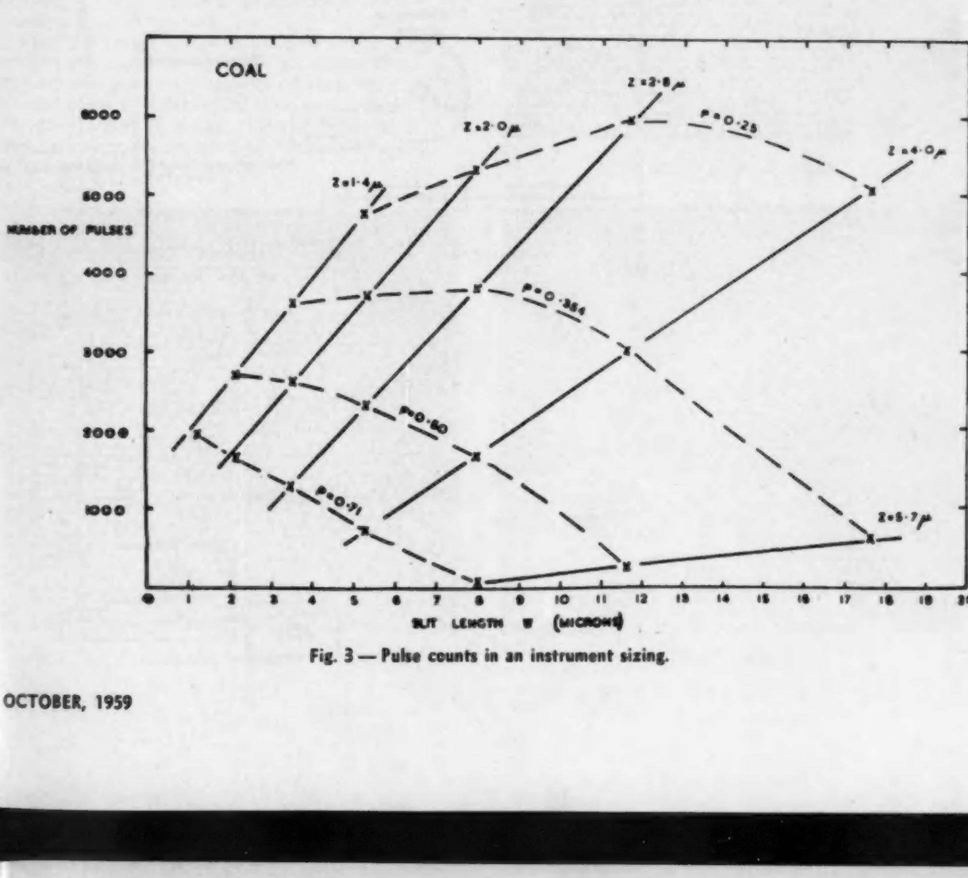


Fig. 3 — Pulse counts in an instrument sizing.

Wide track scanning counts and sizes particles

. . . continued

instrument has been designed round this equation by being able to set values of w and z.

Instrumentation

If a photocell is placed behind the slit w, with the slit unobscured, the output from the photocell will constitute the base line O. When the slit w is completely obscured by a particle the photocell output will be zero, and is the 100% signal level. These pulses are of the type shown in Fig. 2.

To be able to set a low limit of size to the particles counted (the lower limit being z), a pulse amplitude discriminator is used, which when set at some p value between 0 and 100, will pass to the scaler all pulses greater than the p value set. Equation (3) can be rewritten as:

$$\phi(w) = N(w(1-2p) + \bar{z})L \tag{4}$$

where $wp = z$. Using this method all intercepts greater than z can be recorded.

In this equation there are two unknowns, N and $\bar{z}$. To obtain N the particles must be scanned with two slits of different size, but the product $pw = z$ kept constant. Using the original equation,

$$\phi(w, z \ \text{constant}) = N(w - 2z + \bar{z})L$$

the number of particles per unit of area is:

$$N = \frac{\phi(w_2) - \phi(w_1)}{(w_2 - w_1)L} \tag{5}$$

By repeating this procedure with ever increasing values of z starting with $z \leq a$, where a is the smallest size of particle in the sample, the oversize distribution is obtained.

A size distribution curve is obtainable by differentiating the cumulative oversize curve.

In practice, $\phi(w)$ is plotted against w and more than 2 w's are used to obtain a z-line. Fig. 3 is a typical example.

A schematic diagram of the instrument is shown in Fig. 4. A conventional microscope and microscopic procedure are used.

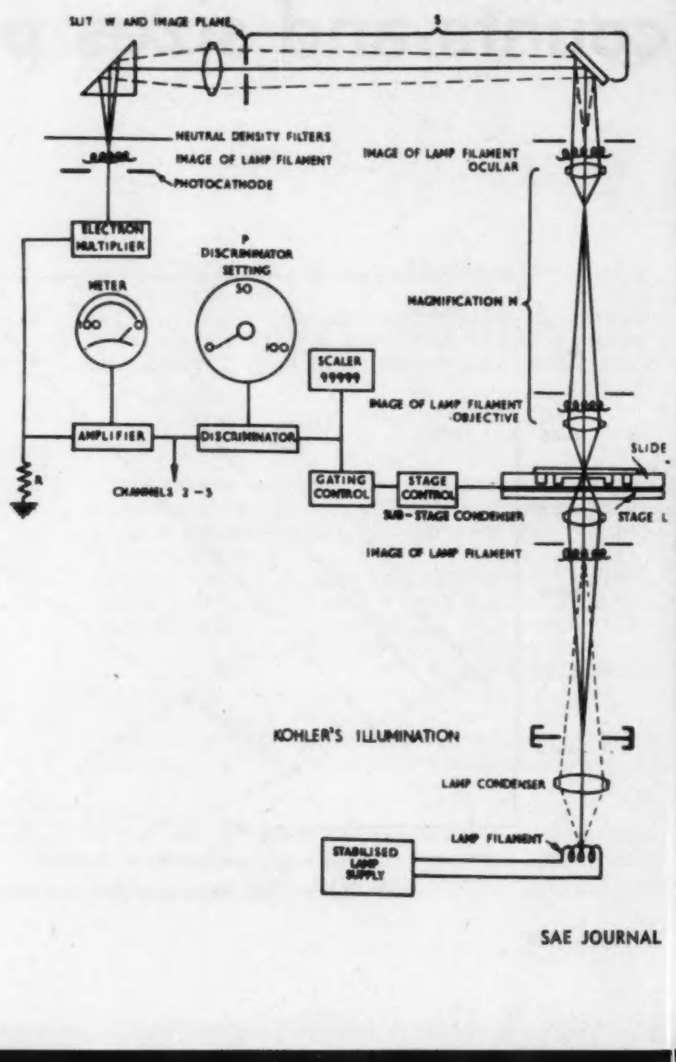


Fig. 4 — Arrangement of scanning instrument.

Bubble Raft Speeds Fatigue Studies

Based on a talk by

G. M. Sinclair

University of Illinois

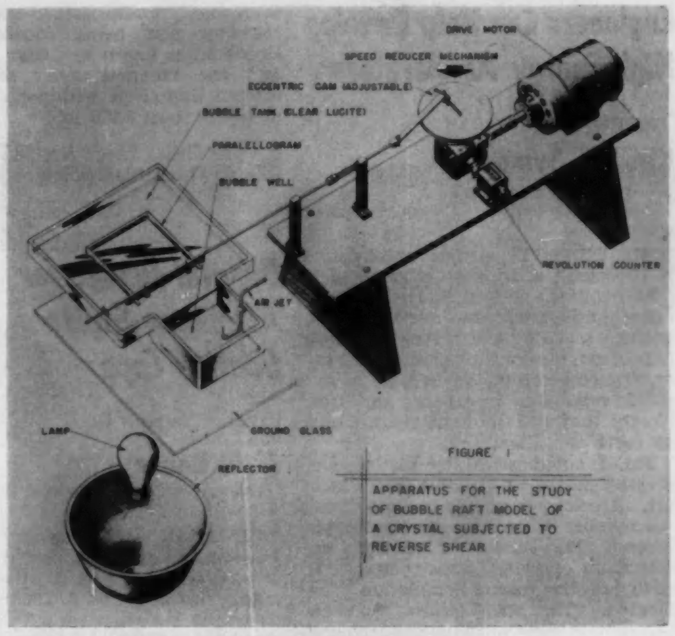


FIGURE 1

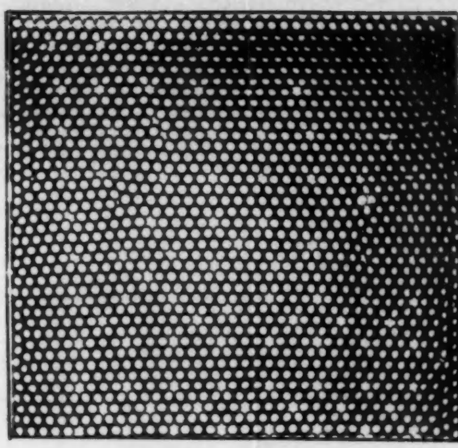
APPARATUS FOR THE STUDY OF BUBBLE RAFT MODEL OF A CRYSTAL SUBJECTED TO REVERSE SHEAR

Straining a bubble covered dish has proved to be a helpful analogy in the study of the nucleation and growth of fatigue cracks. For years it has been clear that these cracks are associated with localized plastic deformation of metals under cyclic loadings. The bubble raft is now one of the techniques of illustrating the dislocation theory of plastic deformation. The raft shows visually, in two dimensions, many of the salient features of dislocation motion. A diagram of the bubble raft mechanism is shown in Fig. 1.

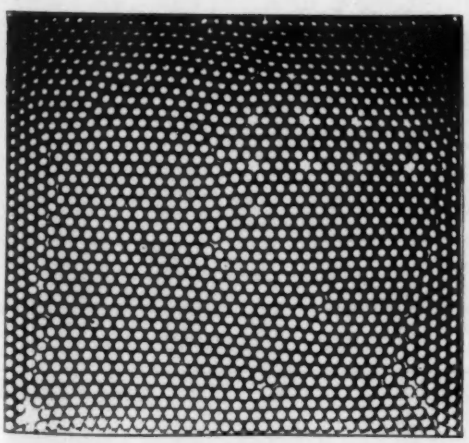
An example of the operation of the raft is demonstrated by Fig. 2.

In Fig. 2 bubbles have been broken to produce 7% vacancies uniformly distributed throughout the surface. After two shear cycles it is evident that the vacant sites are carried along in groups by dislocation and not by the sites moving independently. The vacant bubble sites correspond to missing atom sites in a metal. After five cycles a large crack has formed in the lower left-hand corner of the raft.

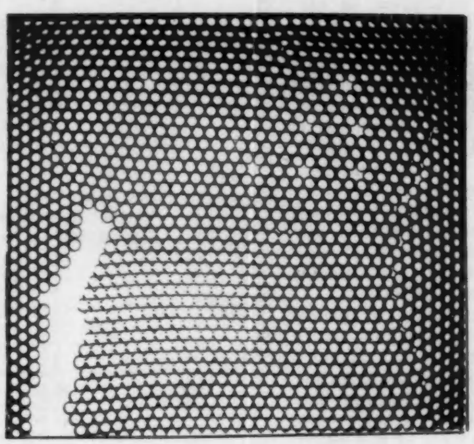
The bubbles around the crack correlate with hardness studies made on aluminum. The bubble pattern is nearly perfect, which is equivalent to recrystallization and softening, in the case of metal. This phenomenon has also been observed in the metal around a fatigue crack in aluminum.



After 0 cycles of shear.



After 2 cycles.



After 5 cycles.

Fig. 2 — Development of fatigue cracks after shear loading is demonstrated by the 2-dimensional bubble raft analogy. The uniformly distributed vacancies in the raft move by dislocation to form the equivalent of fatigue cracks. The effective recrystallization of metal near a fatigue crack is also illustrated.

Engineers Can Help Develop High-Energy Accelerators

Excerpt from paper by

Keith R. Symon

University of Wisconsin and
Midwestern Universities Research Association

HIGH-ENERGY particle accelerators represent a rapidly growing field that requires the best efforts of theoretical and experimental physicists and engineers. They are among the most important, most complex, and most expensive research tools now used in scientific research. In expense and complexity they are, perhaps rivaled only by earth satellites.

Fig. 1 summarizes the history and present status of particle accelerator art. Accelerator energy is plotted versus number of protons accelerated per second. The solid dots represent accelerators already constructed. In each case the year of completion is indicated. The open circles represent the estimated performance of accelerators now under construction or contemplated, together with the estimated dates of completion. In addition, question marks indicate the possible performance characteristics and possible completion dates for fixed-field alternating-gradient (FFAG) accelerators. The upper question marks represents a possible beam intensity from an FFAG accelerator at 15 bev. The question mark to the lower right represents the energy and beam intensity that would be required from a conventional accelerator to achieve collisions equivalent to those produced in a 15-bev colliding-beam accelerator. The curves running down to the right through the graph indicate the maximum energies and beam intensities achieved as of various dates.

The development of particle accelerators has now reached the stage where extensive development of theoretical and experimental techniques is required. As an example, the Midwestern Universities Research Association (MURA) laboratory utilizes an IBM 704 computer full time on accelerator problems. A spiral sector electron model, which has been constructed, was designed entirely with the aid of a digital computer. As a consequence, the dynamical properties of the electron orbits in this accelerator were well understood even before the accelerator was constructed. The theoretical predictions have been amply confirmed by experiments with the accelerator.

Experimental techniques in many areas, including high vacuum techniques, magnet design, radio frequency circuitry, and methods of particle detection, are required to build and utilize modern high-energy accelerators. To give just one example of the many technical problems that need to be overcome, the alternating-gradient accelerator now being constructed at Brookhaven has a diameter of 966 ft and the magnets must be aligned around this circle within an accuracy of better than 0.020 in.

To Order Paper No. 68T . . .
on which this article is based, see p. 6.

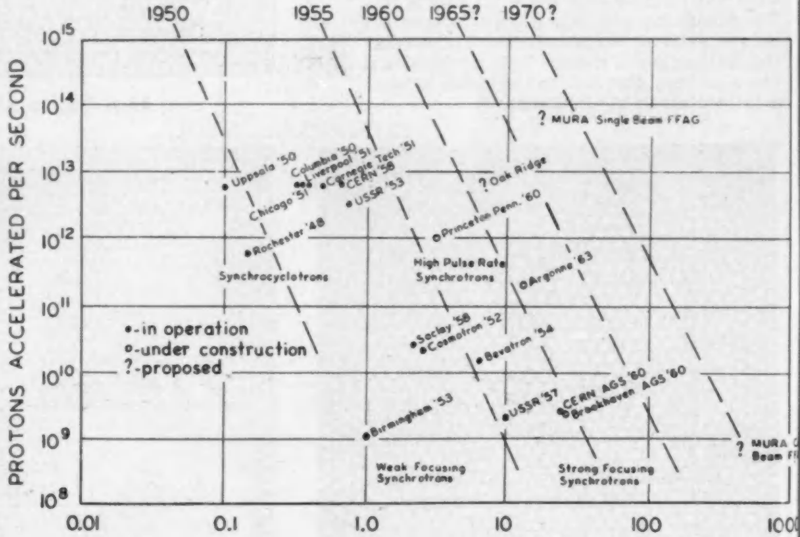


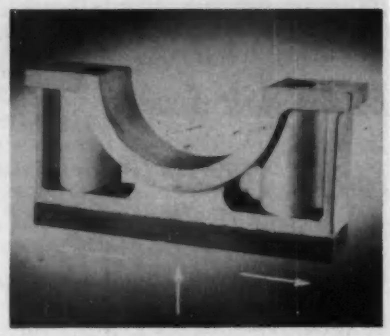
Fig. 1 — Beam intensity and energy of high-energy accelerators.

Bimetal Design for Aluminum Engine Bearing Caps

Excerpts from paper by

A. F. Bauer

Doehler-Jarvis Division, National Lead Co.



THE MAIN expansion problem between iron and aluminum in cast aluminum engines is at the bores of the crankshaft bearings. A 0.004 additional clearance can occur for a 2½ in. diameter bore at 300 F. This makes the engine noticeably noisier. One solution is to cast a steel strip into the bearing cap.

As the aluminum chills in the die, it wants to shrink. But the steel strip opposes the free shrinkage, and residual stresses are set up in the bond area. This puts the steel under a compressive stress and actually bends it outward. The cap is then machined and fastened to the block. When the engine operates and the temperatures go up, the aluminum expands more than the steel strip. This relieves some of the residual stress and the original bending in the steel strip is reduced. Since the cap is locked in both legs, the bore of the cap will get smaller in the vertical direction. The shape of the bore is not exactly round, but the expansion is controlled in the most important direction.

The amount of deformation of the cap can be adjusted by varying the thickness of the steel strip. It is possible to fasten the steel strip to the cap in other ways than the bond formed by casting. Any fastening method of a mechanical or metallurgical bond, which is stronger than the residual stress, will give satisfactory results.

SAE NEWS

SAE West Coast Meeting Report

Technical papers and discussions covering much of the automotive field highlighted SAE's 2nd International West Coast Meeting at Vancouver, B.C., August 10-13.

SESSIONS on the operation and maintenance of heavy-duty on- and off-highway vehicles and of diesel engines on land and sea were well attended. Also popular were technical papers on marine gasoline, engine noise, mechanic training, progress in truck tires, design, and use of heavy-duty accessories and systems, fuels and lubricants, braking equipment, and lubrication as a maintenance operation.

Hosted by SAE's British Columbia Section and sponsored by the Society's Diesel Engine, Fuels and Lubricants, Transportation and Maintenance, and Truck and Bus Activities, the Meeting featured 21 papers which kept truck and bus-minded automotive engineers from throughout the Continent on their toes.

The SAEers climaxed each paper presentation with thought-provoking question periods, punctuated their business sessions with "social periods," and left Canada's "evergreen playground" wiser on the problems of heavy-duty on- and off-highway vehicle operation.

Also active at the Meeting were the Northern California, Northwest, Oregon, San Diego, Southern California, and Spokane-Intermountain sections of SAE and the Salt Lake City Group.

The Meeting was put into motion with greetings from C. H. Willis, General Chairman.

Guest speaker at the Banquet was Dean Gordon M. Shrum of the University of British Columbia who spoke on The Challenge of Science. Toastmaster at the Banquet was J. G. Holmstrom, vice-president, Engineering, Pacific Car & Foundry Co.

Ladies and gents attended a field trip through the MacMillan & Bloedel Plywood Plant and Saw Mill on the last day of the Meeting. From rough log to finished lumber and plywood was watched with interest by all. Special programs, developed for the ladies attending the Meeting, included tours, fur show, and visits to Vancouver's "Theatre Under the Stars."

Technical session chairmen were: L. M. Landwehr, Texaco, Inc.; G. T. Perry, Shell Oil of Canada, Ltd.; M. E. Winters, City of Portland Department of Public Works; and V. C. Peterson, Municipal Railway of San Francisco.

Capsules of Papers

Lubrication — In studying oils under an electron microscope, many oils have additives that appear as large undissolved particles or colloids. These oils in use are the least successful. Additive levels over 25 millimols per gal begin to be of doubtful value as calcium, barium, zinc, sodium, vanadium, and others, whether present in the fuel, the air or the oil, can and do form deposits on the valve faces, and this deposit in time flakes off, resulting in a valve blow, which in turn gutters the valve. Attempting to prevent this by changing the metallurgy of the valve usually prolongs the valve life but does not prevent the ultimate failure and the repair costs more.

Additive levels should be kept as low as possible to prevent this from happening. In addition, the oil should be noncorrosive to all the engine metals and must wet all the metals, and in both cases at the highest operating temperature. (Paper 84T)

Recent Developments in Tires — Several remarkable new synthetic materials for tires may end dependence upon foreign-grown natural rubbers. Among the new synthetics are: Goodyear Natsyn, Firestone Coral, Goodrich Ameripol SN, Shell Polyisoprene, Phillips Petroleum CIS Polybutadiene, and Firestone Diene.

All manufacturers of rubber chemicals are currently engaged in providing new accelerators, antioxidants, and antizonants to the rubber compounders. Among these are the sulphenamide accelerators which make it possible to safely process the scorchy tread furnace blacks of today. Many antizonants which greatly improve resistance to weathering have been made available. (Paper 84U)

On-The-Job Mechanic Training — A motor mechanic's training is never finished. Yearly models with changes in such intricate mechanisms as automatic transmissions, power brakes and steering, air conditioning units make on-the-job training a continuous necessity.

In addition, the yearly increase of cars and trucks on the roads de-

SAE WEST COAST MEETING GENERAL CHAIRMAN C. H. Willis (left) discusses program activities with banquet speaker Dean Gordon M. Shrum (center) and SAE president Leonard Raymond.

mands a steady increase of service people who have to be trained from the ground up. General Motors Products of Canada, Ltd. has established 10 permanent training centers in Canada and 30 in the United States. (Paper 84V)

Automotive Electrical Systems — Improved and standardized electrical equipment is needed for use on off-the-highway vehicles and trucks used in the lumber industry. Specific proposals include: standardization of battery sizes to cover the entire logging industry; development of a battery, or battery heater, for faster starts in cold weather; improved construction and increased capacity for electrical components; and standardization on the 24-v system to simplify maintenance, reduce initial cost, and cut inventories. One fleet of 170 vehicles now requires 15 different sizes of batteries, some differing in dimensions by as little as a quarter-inch. The same fleet also requires 24 different generators, 36 different starters, and 10 different voltage regulators. (Paper 85T)

Spark Arresters — The logging industry will continue to resent using spark arresters unless great strides are accomplished in their development and adaptation. The following requirements must be met: 1. They must be relatively small and light weight. 2. They must be of such materials and be sufficiently rugged to withstand high temperatures and unavoidable abuse in the field. 3. They must be adaptable to being mounted so they do not obstruct the operator's vision. 4. They must operate efficiently with low back pressure. 5. They must be easily cleaned. 6. They must be of multi-purpose design. 7. They must be manufactured at reasonable cost.

A survey of logging companies indicates that power saws have started many woodland fires. Here the development of adequate spark arresters is imperative.

Spark arresters applied to motor vehicles and larger engines are operating effectively, but the risk definitely is greater with gasoline engines than with diesels. Arresters should not only prevent carbon particles from escaping, but should also function to reduce exhaust noises and to prevent water from entering fuel systems. (Paper 85U)

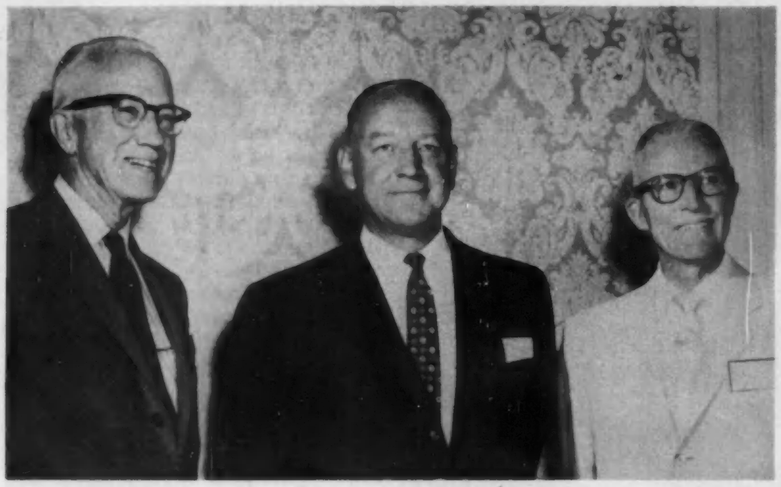
Air Cleaners — The porosity of a filter element may vary according to specifications. It can be made so tight that almost perfect efficiency is achieved, but its life or dirt holding capacity is very small. The more porous the media, the coarser the dirt it will pass initially, until a bed of dirt is built up on the element. The maximum wear in an engine is caused by dirt of about 20 microns. Thus, it is advisable to keep the porosity well below this point.

The oil bath air cleaner is a definite improvement over the other types of air cleaners. It has high efficiency. Its dirt holding capacity is higher than the strainer type. This air cleaner collects its dirt on the dirty air side of the cleaner, and it is never necessary to break any connection between the clean air side of the cleaner and the engine. It works equally well on any quality of engine oil. Most important of all, the oil bath will not pass any dirt larger than about 5 microns and some can guarantee even smaller maximum size.

In spite of these advantages, there are also some disadvantages. The cleaner must be mounted in a vertical position. It loses some efficiency at low air flows. The size and round shape of this type often creates a mounting problem. And it is reported to be a dirty job to service a unit. (Paper 85V)

Ashless Detergent Oils — Ashless detergent additives are superior to metallic additives, and also to base oils, for lubricating two-cycle gasoline engines used on power saws, scooters, and outboard installations on boats. Both field and laboratory tests have shown that the ashless detergents provide excellent deposition control, thereby reducing ring sticking, spark plug fouling, performance loss due to port plugging, and piston scoring. When lubricating oils containing ashless detergents were used in engines already in poor condition a general cleanup occurred and performance improved. (Paper 65V)

Meeting Today's Fuel Specs — The 1959 automobile has so much power producing potential and so many power devices occupying the available space under the hood that the fuel system is held at a relatively high temperature. This definitely aggravates any vapor



BURDETTE TROUT (left) was reservations chairman of the Meeting with Alan Reid (right) in charge of finances. Banquet toastmaster was J. G. Holmstrom (center) of Pacific Car & Foundry Co.

West Coast Meeting Report . . . continued

lock tendency. Simultaneously the fuel is expected to provide almost instantaneous smooth power when the engine is first started, which is possible only with a fuel of moderate volatility. Control of the Reid Vapor Pressure is mainly by the addition of butanes, while the distillation is controlled by the selective choice of the blending components going into the finished product. Today five or more base components, some with narrow distillation ranges, must be blended into the two or more grades of gasoline marketed by the refiner in such a way as to obtain the optimum octane advantage without upsetting the volatility characteristics. Since it is axiomatic that blending formulae must be developed which will balance production of all stocks with the market demand for the various grades, the process units must provide balanced distillation ranges in the finished products. (Paper 86T)

Field Testing of Automotive Lubricants — Extending lubrication intervals results in increased wear of parts. One test was carried out to ascertain the increase in wear caused by extending the lubrication intervals. The lubricant was a conventional soap chassis lubricant. The wear represents the average of the six shackles of a vehicle. The greasing intervals ranged from 1000 to 10,000 miles and the total period of operation was 20,000 miles. The average wear of the shackle part of a certain make vehicle was relatively large, being 14 thousandths of an inch at 5000 mile greasing intervals. A more important result of this test was the large increase in wear as the greasing interval was increased. At 1000 mile periods the wear was 6 thousandths of an inch while at 10,000 mile periods the wear was 19 thousandths. It is apparent from these results that frequent greasing will give the best performance. (Paper 86U)

Deicers Prove Effective — In one controlled carburetor icing field test, a base fuel and three anti-icing additives were compared for stalling tendencies by 120 private motorists operating their own cars over a four-month period. Results were analyzed using a digital computer and show that under atmospheric conditions most conducive to icing (40 F ambient and 100% relative humidity) stalling occurred with the base fuel in 43% of the observation periods. Additives cut this incidence by two-thirds. When stalling occurred, the average number of stalls per observation period was 1.7. Most cars stalled once or twice and only a few cars stalled as many as four times. Some makes of cars appeared more prone to stall than others, and more stalling was encountered with manual chokes than with automatic chokes. (Paper 86V)

Turbochargers — Do They Pay? — Turbochargers easily and efficiently increase the power output of diesel engines in commercial vehicles, but decision is necessary as to why more power is needed. Taking extra power from an engine imposes costs of increased maintenance and parts replacement which may not be offset by service benefits. Does it pay you to traverse the route any faster, or does it just give the drivers more time for convenient coffee stops? (Paper 87T)

Turbochargers in Marine Use — In marine duty the turbocharger and engine can be matched without compromise for maximum efficiency, and this should give excellent performance and reliability. Marine duty is essentially at constant speed, at or near the maximum torque (or BMEP) rating of the engine. Below rated speed, however, the engine does not have to develop maximum torque, since it delivers power only to satisfy the power curve of the propeller, which characteristically demands power according to the cube of its speed. This means that load drops off very rapidly below the rated speed, and thus there is a complete absence of "lug" as found in most other duties. This situation is ideal for turbocharged engines because it requires the turbocharger to be matched to the engine just at rated load and rated speed. (Paper 87V)

Flame Speeds and Pressure Rise Rates — Instrumentation has been developed to display and record simultaneously, on one oscilloscope screen, the pressure-time and reaction front histories in a spark ignition engine. Results obtained with the instrumentation show that in most cases the peak pressure was developed many crank angle degrees after the initial reaction front had completely traversed the combustion space. Thus reaction times can be quite long and of considerable consequence in terms of engine events. Further, the results indicate that the definition of a "flame front" must be related to the system whereby the observations are being made.

Cycle-to-cycle variation of pressure development in a combustion chamber of the type used was not normally due to differences in the

rate at which the reaction front progressed across the chamber. Such rates had essentially constant values once established. The major contribution to the cycle-to-cycle variation was a variable induction period between spark ignition and the establishment of the propagating reaction.

Measurement was made of the rate of progress of the reaction for a limited number of specially selected fuels. Contrary to expectations, the rate of propagation through isooctane-air was about the same as through such preignition prone fuels as the nitroparaffins. The rate of propagation through methanol-air was the fastest observed. For comparison, the maximum rate for methanol was found to be 180 fps and this occurred at an equivalence ratio of 1.45; for isooctane the fastest rate was 150 fps at an equivalence ratio of 1.15 and for nitromethane the maximum rate was 160 fps at an equivalence ratio of 1.0. (Paper 83V)

Parking and Emergency Brakes — Efficient spring brakes which function both as parking and emergency brakes and also bring vehicles to smooth stops have been developed. The brakes consist of simple spring-loaded cylinders using air pressure to compress the springs. With no air in the cylinders, the brakes are on. If air pressure is lost, the brakes function automatically. As parking brakes they are operated manually from the drivers cab. (Paper 88T)

Liquid-Cooled Brakes — Heat dissipation by radiation has just about reached its limit with drum brakes. However, liquid-cooled disc brakes have been developed for commercial and off-the-road vehicles. These brakes are made from a combination of aluminum, steel, copper, and lining and utilize the same coolant as the engine.

A transcontineтal run on which a loaded trailer truck combination sought out all difficult hills reported by truck operators compared the efficiency of drum and liquid-cooled disc brakes by automatic recorders and observations. Throughout the 6000 mile run the temperature of the drum brake sometimes exceeded 500 F whereas the disc brakes remained close to ambient temperature. Such an installation will not only promote safety and reduce maintenance costs, but will eliminate downshifting on grades and thereby permit the vehicle to travel the required distance in a shorter length of time. (Paper 88U)

Hydraulic Retarder — A new hydraulic retarder has been developed to provide a means of decelerating vehicles and for controlling the forward speed of vehicles while descending long grades. This form of braking has a capacity which is far in excess of what the best commercial vehicle service brakes are capable of absorbing.

The retarder system, working on an entirely different principle than friction braking, transforms the rolling energy of a vehicle-in-motion into heat, most of which is then dissipated through the vehicle cooling system. Some of the heat generated by the retarder is also dissipated by radiation from the retarder's specially finned outer surfaces.

This retarder works on a fluid coupling principle, and has no frictional surfaces to wear or require adjustment. The retarding action can be applied at any vehicle speed and to any desired degree of loading. It permits the driver to safely control a vehicle on practically all types of adverse road conditions. (Paper 88V)

Engine Rumble — Certain engine design and operating variables affect the occurrence of rumble through their influence on the combustion process. The rumble requirement of an engine is increased if: 1. compression ratio is increased; 2. air-fuel ratio approaches best power mixtures; 3. inlet air humidity is decreased; 4. inlet air temperature is increased; 5. engine load is increased; 6. engine speed is increased. Studies indicate, however, that higher compression ratios and correspondingly higher engine efficiencies can be reached without objectionable rumble if oils and fuels are carefully selected. It has been demonstrated that cars can be operated satisfactorily at compression ratios as high as 12:1 even under light-duty driving conditions. (Paper 83U)

Exhaust Brake — An exhaust brake has been developed which converts a vehicle's engine into an air compressor going down hill, maintains engine operating temperatures, and reduces the dangers of valve warpage and engine parts strain. The actual compression brake consists of a valve bolted directly to the exhaust system as close to the exhaust manifold as possible. The compression brake is made of stainless steel. The compression brake as a retarder in controlling vehicles on down-grades is said to greatly increase the life of brake linings, lower brake maintenance costs, and control engine temperatures. It is expected that the added safety will make the compression brake, in the not too distant future, a necessity rather than an accessory. (Paper 88W)

Marine Engine Octane Rating — As part of a marine octane rating program 65 engines were tested between 1956 and 1959. Sixteen different production models marketed by seven different marine engine manufacturers were tested. Conclusions based on the test results include: 1. octane requirements of the marine engines tested ranged from 72 octane to 92 octane (Motor Method). 99.5% are satisfied with a marine gasoline of 88 Motor Method; 2. Inboard marine gasoline engines require fuel with a particular Motor Method octane rating. Automobile engines usually require a fuel having a particular octane number determined by the Research Method; 3. In general, marine engines had higher octane requirements with high sensitivity automobile type gasoline than with low sensitivity marine white

THE "LOW DOWN" is given by SAE British Columbia Section's first chairman P. J. Schrodt (1946-47) (left) to incoming chairman T. L. Coulthard (1959-60) of the University of British Columbia. Professor Coulthard was program chairman at this year's West Coast Meeting in Vancouver.

FACTS . . . from SAE literature.

(Except where a charge is specifically indicated, SAE Journal will be glad to supply on request one copy of any of the pieces of SAE literature described. Address "Literature," SAE Journal, 485 Lexington Ave., New York 17, N. Y.)

SAE MEMBERS ARE AT WORK IN:
100% of all companies making passenger cars, trucks, airplanes, aircraft powerplants, helicopters, missiles and drones, tractors, diesel engines, and earthmoving equipment; 95% of those making buses; 90% of the 50 largest truck fleet operators; 85% of the 20 largest airline operators; and 84% of those making industrial engines.

This is a "fact" lifted from hundreds in the latest "FACTS about SAE Journal," out this month.

375 ENGINEERS ON SAE'S IRON AND STEEL COMMITTEE and its subgroups set the standards and write the ferrous metal specifications needed for automotive use in the $32,000,000,000 a year steel industry . . . according to SAE's booklet on "Steel."

E. P. White

"How to Make the Student Branch Click" is a made-to-order booklet to help organize and develop a well-rounded student program. This is how Student Committee Chairman E. P. White referred to it recently. At the same time, he offered his committee's cooperation in developing faculty and student interest in engineering schools where SAE is not represented.

HINTS TO SPEAKERS — from members who have listened to many technical papers, and from those who have made successful presentations — are passed along in the pamphlet titled "A Clear Presentation."

Then there's the folder "Clear, Simple Illustrations" to further help the SAE paper-preparer.

Both pieces were authored by SAE Meetings Committee for prospective authors of SAE papers.

"SAE CONTRIBUTES to every military and civilian aircraft produced in America . . . from the fastest jet to the hovering helicopter." So says the pamphlet "SAE Has Wings" . . . which goes on to tell just *how* SAE Technical Committees provide tools for the aircraft industry. SAE's Membership Committee prepared this one.

type gasoline; 4. Advancing ignition timing a few degrees beyond best power at full throttle increases octane requirements by several numbers but has small effect on power output. No increase in maximum engine rpm was observed in engines installed in boats when ignition timing, set at the manufacturers' recommended settings, was advanced an additional 5 or 6 deg; 5. Many engines producing full throttle maximum power on a given fuel will not yield higher engine power or rpm on higher octane fuel, regardless of ignition timing; 6. Engine octane requirements are greatly reduced when engine rpm is reduced slightly by easing back the throttle; 7. A better breathing and mixture distribution was achieved on one model by a change in carburetor and manifold design which lowered the octane requirement by two numbers; 8. The octane requirement of an engine at full throttle was increased from one to four numbers when a twin-engine boat operated on only one engine and its full throttle rpm was reduced 400 to 500 rpm; 9. Practically all field service complaints were remedied by timing the engines and setting the distributor points to the manufacturers' recommended settings. The other instances were caused by the improper grade of gasoline for the particular engine model. (Paper 83T)

– 76 F OK for Diesels in Yukon — Four hours exposure to temperatures as low as – 76 F has been found practicable for diesel trucks in the Yukon providing the vehicle keeps moving. Prolonged exposure results in a stoppage of fuel flow to the engine. The initial manifestation of fuel trouble is a clogging of fuel filters as a result of fuel temperature falling below the cloud point. Emergency relief may be gained by the removal of fuel filter cartridges — but this of course has all the attendent hazards to the fuel system. Recirculation through fuel pump and engine continues to be reduced until finally fuel flow stops. The fuel provided is called Arctic Diesel Fuel and has a pour point of – 60 F and an A.P.U. gravity of 39 deg. Operation down to – 65 F does not present any problems with this fuel. To operate below these temperatures consistently would require fuel preheating. (Paper 87W)

SAE STANDS

on member-to-member services, says Council Policy Statement

"WE still enjoy freedom of enterprise in this country, both in the field of engineering societies and industrial endeavor. We all have the same opportunity to succeed as well as fail.

"The group or groups which come closest to serving the needs of their members will be the ones that survive."

This was a key statement in the declaration of policy recently established for SAE by its Council in response to scattered industry comment that "there are too many engineering societies and too many meetings."

The five-point policy statement emphasizes that:

- SAE has an obligation to furnish the most effective and useful technical information it can produce. This was implicit in the contract SAE entered with each member upon his being accepted for membership.
- SAE member-planners seek out those most competent to contribute this desired technical information . . . seek the best men available on the given project or problem.
- So long as technology continues to grow and advance, men with specialized interests will always feel their needs require a new society to service them. . . . The group or groups which come closest to serving the needs of their members will be the ones that survive.
- It is the responsibility of industrial management to make its own determination and to partake of what each engineering society makes available as circumstances will permit.
- The more effective an engineer becomes as a result of his participation in SAE, the greater the benefit to his employer . . . as reflected in the work performed by the engineer at his desk. . . . The extent to which management actively encourages participation by its engineers may be the extent to which the engineer's loyalties to his management will grow and solidify. His susceptibility and his search for outside relationships with management are, likewise, likely to shrink in inverse proportion.

The policy statement adopted by the Council grew directly from discussion of multiplicity of technical meetings by the Aircraft Activity Committee, starting back in April of this year. The results of that discussion — developed as a policy statement — were brought to SAE Council at its June meeting in Atlantic City by W. C. Heath, vice-president for Aircraft. Explaining the problem and the occasion for discussion by the Aircraft Activity Committee, Heath told Council:

W. C. Heath

"Some of our committee members have heard statements made in the aircraft industry that there are too many engineering societies and too many meetings. The implication here is that some management people are concerned that the societies and society meetings are a drain on the time and energy of men in the engineering departments of their companies. . . . Some of these management people have said that 'something ought to be done about it'."

Then Heath went on to present the following statement of principles, which — at its September meeting — the SAE Council adopted as the official statement of the Society's position.

SAE Policy on Multiplicity of Engineering Societies and Meetings

1. . . . . SAE has an obligation to its more than 24,000 members and 5000 enrolled students to furnish the most effective and useful technical information the Society can produce.

This was implicit in the contract SAE entered into with each member upon his being accepted for membership in the Society.

Therefore, SAE's task is to serve *the individual* as best it can, within the limits of its facilities and resources in each of the technical areas it covers.

2. . . . . All the services SAE renders — its meetings, papers, publications — are determined by the members themselves.

They decide what is needed at any given time; what information will be most useful; what will prove most interesting.

Influencing the decision of SAE's member-planners are the technical problems they know SAE members face at their desks, and in their plants . . . the impending challenges for improved performance from machines, materials, and proccesses; changing requirements brought about by influences, both technical and non-technical, call for new break-throughs.

Then SAE member-planners seek out those most competent to contribute this desired information. They tap sources in industry and in universities and research centers in this country and abroad . . . always seeking the best men available on the given problem or project.

3. . . . . So long as technology continues to grow and advance, there will always be men with specialized interests who feel that a new society must be formed to service their needs.

The first engineering society was the Society of Civil Engineers, as distinguished from military engineers. Since that time scores of engineering societies have developed, and new ones will undoubtedly continue to emerge in the future.

We still enjoy freedom of enterprise in this country, both in the field of engineering societies and industrial endeavor. We all have the same opportunity to succeed as well as fail. The group or groups which come closest to serving the needs of their members will be the ones that survive.

4. . . . . The extent to which individual companies provide facilities and wherewithal to their engineers to participate actively in SAE is purely a company matter.

It is understood and appreciated that a company may modify its attitude on SAE participation by its engineers in accordance with the overall climate in which it is operating at any given time. Quite naturally, these situations will vary among companies in the industries served by SAE. When some may be enjoying prosperity, others might be engaged in some belt tightening.

So, it seems to SAE that it is the responsibility of management to make its own determinations and to partake of what SAE makes available as circumstances permit.

5. . . . . SAE's job is to contribute to the growth and development of engineers in their technical fields. Its objective is to equip men, through the technical information it distributes, and the associations developed through SAE participation, to carry out more effectively

their assignment for their employers.

By the same token, the greater the emphasis SAE can give to recognizing each man for his individual contribution to a project, for recognizing the INDIVIDUALITY of the INDIVIDUAL, the greater the satisfaction he will derive from his membership and participation in the Society.

The more effective an engineer becomes as a result of his membership and participation in the Society, the greater the benefit to his employer, as reflected in the work performed by the engineer at his desk.

SAE greatly augments and supplements what management tries to do in satisfying the engineer's search for individuality. Management becomes a party to this recognition of the individuality of the individual by encouraging his participation in SAE, by giving him the time and the stimulation to participate in Society activity.

The extent to which management actively encourages the participation of the man, leading to his professional recognition by his peers, can be a means whereby his loyalties to his management will grow and solidify. His susceptibility and his search for outside protection in his relationships with management will likewise shrink in inverse proportion.

Sperry Award to First Jet Transport Designer

1959's ELMER A. SPERRY AWARD goes to de Havilland Aircraft Co., Ltd., as creator of the world's first jet passenger transport.

SIR GEOFFREY DE HAVILLAND, president, and C. C. Walker, early director, received the award on Oct. 7 at the Conference Dinner of the Biannual Joint Meeting of the Royal Aeronautical Society and Institute of Aeronautical Sciences at New York's Hotel Astor. The late Major Frank Halford, early chairman and technical director, was similarly honored — in memorium.

The company was cited "for the vision, courage, and skills displayed in conceiving, developing, and producing the world's first jet-powered passenger transport aircraft, the de Havilland Comet, powered by de Havilland 'Ghost' jet engines." "This accomplishment," the citation continued, "is especially noteworthy as providing the example and inspiration which has brought into being the succession of efficient, high-performance, subsonic jet transports that have followed under various leaderships throughout the world."

Sir Geoffrey De Havilland

T. P. Wright and William Littlewood are SAE's representatives on the Board of Award. In addition to SAE, the award is sponsored by American Institute of Mechanical Engineers, American Institute of Electrical Engineers, and the Society of Naval Architects and Marine Engineers.

SAE NATIONAL MEETINGS

- **October 5–10**

  National Aeronautic Meeting (including manufacturing forum and engineering display), The Ambassador, Los Angeles, Calif.

- **October 26–28**

  National Transportation Meeting, La Salle Hotel, Chicago, Ill.

- **October 27–29**

  National Diesel Engine Meeting, La Salle Hotel, Chicago, Ill.

- **October 28–30**

  National Fuels and Lubricants Meeting, La Salle Hotel, Chicago, Ill.

SHOW . . .

. . . engineers how to create, '59 graduate urges.

SAE ENROLLED STUDENT RAYMOND ERLER '59 authored an article titled "Engineering! Education!" in Bradley University's *Bradley Engineer* last May. "We graduate," he said (just about as he was to do so) "with a mental scope far narrower than desirable and a much too limited range of variables with which to create."

Industry cries for "quality" engineers, he points out . . . tells young engineers to "be creative and to think originally." "Yet," he queries, "what effort is made in higher education to develop real creativity, original thought, and imagination?" Pursuing this point, he goes on to say:

"How much better it would be if they would stop telling us to be creative and start giving us the courses that will develop it! Certainly we realize that creativity requires a given amount of inherent ability. But it seems to be a defeatist attitude, not common to the sciences, to refrain from stimulating and drawing forth this talent which lies dormant in many engineers.

"The fact is that the average engineer is limited in his creativity by the

narrow range of variables in his field. For example, the psychologist writes his philosophy in terms of motives, drives and egos. The mathematician expresses his philosophy with symbols for quantities and molds them into mathematical equations. The engineer sees his philosophy in terms of forces, laws of nature and other variables in his field.

"There are certain mind sets, in other words, that seem to prevent us from thinking in full awareness. Unfortunately the average student engineer is barely aware that there are such things that hamper creativity and logical analysis, nor does he learn how to remove such conditions.

"Unfortunately many practicing engineers and college-senior engineers like myself have not had the benefit of an education with a broad base. But I believe we are intelligent enough to see the advantages of such an education and encourage the trend."

'58 Wright Medal to Van Every

. . . a two-time winner.

Kermit Van Every

PRESENTATION of the 1958 Wright Brothers Medal to Kermit Van Every at luncheon on October 8 during SAE's National Aeronautic Meeting in Los Angeles makes him a "two-time" winner of the Award.

This time, the medal goes to him for his paper "Design Problems of Very High Speed Flight" . . . which was judged the best 1958 SAE paper under the terms of the Award. It deals with design problems of manned aircraft operating from 1300 to 25,000 mph and covers such topics as flight paths, aerodynamic heating, stability and control, and human effects. (July 1958 SAE Journal carried an abridgment and the full paper is in 1959 SAE Transactions.)

A paper he presented in 1948 on "Aerodynamics of High Speed Airplanes" won him the same award for that year.

Van Every is chief of the aerodynamics section of Douglas Aicraft's El Segundo Division. He is a graduate of Stanford University, where he started his career of award winning in 1939 by being tendered the Guggenheim Award for the best mechanical engineering thesis. He went to work for Douglas immediately after graduation and has been there ever since.

Serving on the Board of Award which selected Van Every were A. E. Lombard, Jr., E. H. Heinemann, and D. R. Berlin.

Section Papers...

. . . on uptrend in SAE Transactions.

SECTION PAPERS comprise a greater proportion of the just-issued 1959 SAE Transactions than in any recent year. More technical information of long-term value, in other words, is being presented to Section — as well as to National — meeting audiences.

In 1958, for example, SAE Transactions carried only four Section papers — two of which came from the Central Illinois Section's Earthmoving Conference. This year, Readers Committees selected for publication in full nine papers . . . from six different Sections. The Earth Moving Conference provided one for 1959; Detroit, Southern New England and Southern California, two each; and one each came from Metropolitan and Texas Gulf Coast. . . . One of the two from Southern California won a Wright Brothers Award as the best paper on an aeronautics subject.

This improved contribution to the Society's technical literature by Sections is reflected by these facts:

- About 12% of the papers in 1959 Transactions came from Section sources; about 6.5% in 1958.
- About 9.7% of the pages in 1959 Transactions were filled by Section papers; about 7.3% in 1958.

All of the Section papers selected for 1958, 1959, and (so far) for 1960 SAE Transactions, have emanated from nine of the Society's 41 Sections. . . . All five of the Central Illinois papers grew out of that Section's annual Earthmoving Conference. Three others of these 17 came from Metropolitan Section; two each from Southern California and Southern New England; and one each from Cleveland, Milwaukee, Detroit, Texas Gulf Coast, and Philadelphia.

SAE SECTIONS

. . . and their industry.

MORE AND MORE SAE SECTIONS are making real impact on the engineering phases of industry localized in their territories . . . AND their collective activity is assuming industry-wide proportions.

For instance ———

- Milwaukee Section's lecture series on "Engineering Know-How in Engine Design." Started some eight years ago, it is now an important forum of six annual lectures on basic engine design. (Each of the series is being made available in SAE Special Publication form.)
- Southern New England Section's lecture series last year on "Anti-friction Bearings" which will be available to industry as an SAE Special Publication.
- Central Illinois Section's annual Earthmoving Conference — now in its tenth year — brings to the territory a meeting of national caliber, generally accepted as the earthmoving industry's most important annual event.
- The Aircraft Production and Air Conditioning meetings scheduled annually by Texas Section — where the cost of the afternoon and evening sessions, and the dinner are included in the admission fee . . . a "package meeting" as it were.
- Cleveland Section's Annual Transportation Meeting is run on the same order.
- "The Three Ring Circus" — Detroit Section's innovation — where, after the dinner, members with divergent interests adjourn to separately-designed technical sessions catering to those interests. Much valuable engineering know-how is disseminated here.
- The non-dinner, technical, specialized-topic sessions which Metropolitan Section features for the young engineer . . . with emphasis on the discussion periods.
- And the seminars of Southern

SAE SECTION MEETINGS

BALTIMORE
November 12 . . . Hans Hogeman, American Bosch Division, American Bosch Arma Corp. "Injection Equipment for Multi-Fuel Engines." Engineers Club, 6 W. Fayette St., Baltimore, Md. Dinner 7:00 p.m. Meeting 8:00 p.m.

DETROIT
November 9 . . . Three simultaneous sessions. H. O. Flynn, Chevrolet Motor Division, GMC, "Ride and Handling of the New Chevrolet Medium Truck." C. J. Karrer, Detroit Diesel Engine Division, GMC, "New Techniques in Flexible Production of Engines." Earl White, National Northern Division, American Potash & Chemical Corp., "Possible Applications of Explosive Forming of Metals." Rackham Educational Memorial Bldg. Dinner 6:30 p.m. Meeting 8:00 p.m. Dinner speaker: Secor D. Browne, Massachusetts Institute of Technology, "The Russian Scientist and Technician."
November 23 . . . Junior Activity Meeting. "Cross-Country Road Testing." Rackham Educational Memorial Bldg. Meeting 8:00 p.m.

INDIANA
November 12 . . . Ed Blackburne, Engineering Division, Detroit Arsenal, U. S. Army, "Army Automotive Engine Program." Continental Hotel, Indianapolis. Dinner 7:00 p.m. Meeting 8:00 p.m.

METROPOLITAN
November 5 . . . Walter Scott, Grumman Aircraft Engineering Corp., "Problems in Space Exploration." Grumman Aircraft Engineering Corp., Bethpage, L. I., N. Y. Registration: 3:00 to 3:30 p.m. Flight demonstration and plant tour. Sponsored cocktail hour, followed by dinner. $3.00. Reservations limited to 200. No reservations accepted after October 29.

MID-MICHIGAN
October 26 . . . Phil Mazziotti, Dana Corp.; Don Marquis, Saginaw Steering Gear Division. "Torsional Vibration in Drivelines." High Life Inn, Saginaw.

MONTREAL
November 16 . . . A. E. Jennings, Canadian Car Co., Ltd., "Canadian Developments in Bus Design." Sheraton-Mount Royal Hotel. Reception 6:15 p.m. Dinner 7:00 p.m. Meeting 7:45 p.m.

NORTHERN CALIFORNIA
October 28 . . . Dean Noble, Interstate Commerce Commission, "Proposed Regulations." Engineers Club, 206 Sansome St., San Francisco. Dinner 6:30 p.m. Meeting 7:30 p.m.

ROCKFORD-BELOIT
November 9 . . . Plant tour of Fisher Body-Chevrolet plant, Janesville, Wis. Dinner at plant cefeteria. Dinner 6:00 p.m. Meeting 7:00 p.m.

SAN DIEGO SECTION
November 9 . . . Joint Student Meeting. "Cars of the Future."

SOUTHERN CALIFORNIA
November 9 . . . Harve M. Hanish, Litton Industries, "How to Get Out of This World — And Why." Rodger Young Auditorium, Los Angeles. Dinner 6:30 p.m. Meeting 8:00 p.m.

SOUTHERN NEW ENGLAND
November 5 . . . Anderson Ashburn, "American Machinist." Bradley Air Terminal Restaurant, Windsor Locks, Conn. Dinner 6:30 p.m. Meeting 8:00 p.m.

California Section. In two or three meetings on consecutive nights, the particular technical subject is delved into thoroughly under the leadership of experts in the field.

In each case, a desire of the Section to fill a known industry need generated these special features . . . and in each case reactions have been highly favorable throughout the local industries.

Right now, several new ideas are simmering in some Section localities. With the interest now in evidence on the part of Section officers and membership, there is every reason to believe more new features are forthcoming.

SAE Handbook

among "best in all fields."

THE American Library Association is listing SAE HANDBOOK as one of the "best books in all fields."

Here's how it came about: To assist Latin American Universities, Sears Roebuck commissioned the ALA to compile a bibliography of "the best recent books in all fields." ALA came up with a list of 250 — and SAE Handbook was included. The bibliography is being distributed to the universities with the understanding that Sears Roebuck will make financial grants for use in purchasing books of their choice.

You'll

. . . be interested to know that . . .

SWEDEN was added to President Raymond's itinerary on the European tour he is now making. (See pp 94–95 September issue of SAE Journal.) He addressed the Swedish Society of Engineers and Architects, Branch of Mechanical Engineering, on Wednesday, Sept. 30 — on invitation.

SAE members from Indiana Technical College toured the International Harvester Co. on July 31.

Section "Know-How" Sparked at Vancouver

MAIN INGREDIENT FOR SUCCESS in any Section territory is a well-chosen, active Governing Board . . . with each officer fully aware of the area's engineering problems to be solved, and where each has well-defined responsibilities to help point the way to solution. This was a main concept agreed upon by the 40 Section officers and committee chairmen gathered at the pioneer "workshop session" of the Regional SAE Section Officer Conference in Vancouver recently.

As impetus to this end, four suggestions were made:

- Full utilization of a Governing Board's talent . . . with understudies to work with officers, especially where continuity of action is important.

- Have the Section's vice-chairman serve as "personnel officer," or liaison with all Governing Board members, to correlate the jobs being done.

- A "blue book" for each Section job — written or revised by the last man to hold office . . . a continuum of what has gone before, as it were, to serve as a "taking off" point for something new.

- A questionnaire to Section members, requesting from each information on his background in SAE activities, in business and other affiliations, which would assist the Nominating Committee in selecting personnel for Section jobs.

Individual Section "Responsibility and Duties Manuals" to complement present "Section Procedure" were considered a "must" and it was agreed that the Sections Board be requested to determine what Sections now have such manuals and how best they can be made available as a pattern to others.

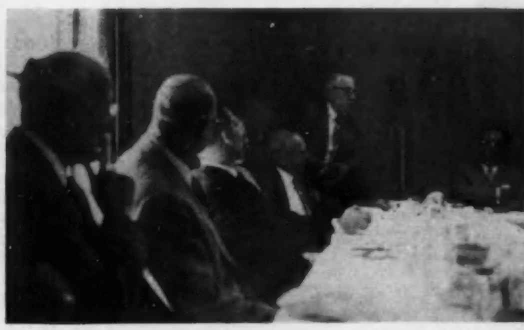
To bring about good attendance at Section meetings, the plant representative appears to be one of the best bets. SAE's product is technical information. To reach its market good "salesmen" are needed, and properly selected plant representatives perform this function ideally . . . particularly when they are appointed with the cooperation of management in the area.

"Hold a good meeting . . . or none," one speaker advised. . . . Or consider the possibility of a "spur-of-the-moment" session designed to take advantage of a good speaker visiting in the territory.

On the subject of Governing Board dinners, "dutch treats" appear to be the thing in the smaller Sections. Many larger Sections budget a set amount for each such dinner meeting and members in attendance split any balance over that amount. Some hold Governing Board meetings in the informal atmosphere of members' homes.

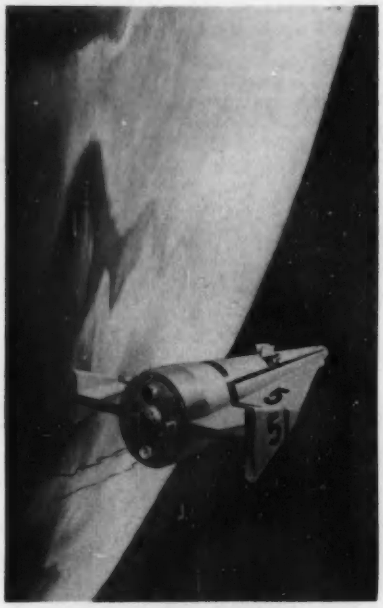
One interesting observation brought out at the Conference was that young engineers and current students are more sophisticated than were their counterparts of not long ago, and will require more specialized technical fare as time goes on. With the new Sections Board as "operating arm" this should not be too difficult a task.

SAE NEWS



HERE — INTENT ON INFORMATION EXCHANGE — is part of the group gathered at the Regional Section Officer Conference on August 10 in Vancouver during SAE's International West Coast Meeting. Standing (right) is W. F. Ford, SAE's Sections Board chairman, who called the Conference; and (left) O. E. Kirchner, Conference leader and chairman of Northwest Section.

Letters from Readers



Re-entry vehicle.

From:
Saunders B. Kramer
Missile Systems Division
Lockheed Aircraft Corp.
Sunnyvale, Calif.

Dear Editor:

R. A. Byers of Lockheed Missiles and Space Division and I are the authors of a proposal on a manned space station recently completed at Lockheed. This proposal is discussed in the article, "Manned Space Flight is Coming," which is based on a paper by Robert D. Roche of Lockheed (Georgia). The article appears on pp. 49–51 of the April, 1959, issue of SAE Journal.

We would like to point out the following errors in the article:

1. On p. 51 a photograph of the artist's painting of the assembled space station is shown (Fig. 3). The smaller vehicle shown at the left-hand side of the photograph is *not* a re-entry vehicle, nor was it ever designed to be one. It would burn to a cinder were re-entry attempted in it. The vehicle shown is an orbital tug, dubbed by its designer, Boardman Rising (who worked with and for the Byers-Kramer team) the "astro-tug." It is the manned orbital assembly vehicle for the concept — literally collecting and coupling the space station from its component sections.

2. The text in column 1 and continuing in column 2 of p. 51 reads: "This is . . . a space station — a permanent orbiting satellite . . . It is a unique astro-tug for assembly of the system. Re-entry vehicles . . . are also shown."

Corrections to these statements are:

(1) "It is a unique . . .," should read, "There is a unique . . ."

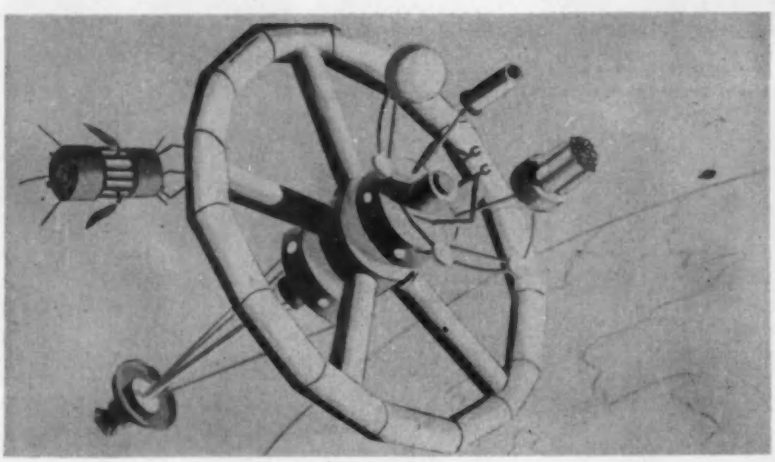
(2) The re-entry vehicles exist but are *not* shown in the picture.

• **Mr. Roche's reply is as follows:**

"The small vehicle at the left-hand side of the photograph was never referred to as the re-entry vehicle in my original paper. It is the astro-tug, and was so called in the original text. The SAE legend under Fig. 3 is certainly open to misinterpretation. The re-entry vehicle that was referred to is the small dot at the extreme right of the illustration, just above the curved surface of the earth. In the original full-scale drawing and presentation slide, this was obviously discernible as the re-entry vehicle. In reproduction and scaling down, the re-entry vehicle was lost in the picture.

"The text in the SAE abstract (p. 51, column 1 and continuing in column 2) should be corrected as Mr. Kramer points out."

Shown at lower left is the picture of the astro-tug and space station that was reproduced as Fig. 3 in the story, and at upper left is a view of the re-entry vehicle. — **Editor.**



Astro-tug and space station.

From:
Charles E. Cohn
7720 Marquette Ave.
Chicago, Ill.

Dear Editor:

In the reports of the SAE Summer Meeting in the July, 1959, issue of the SAE Journal, I note that a number of proposals have been advanced for devices to replace the spare tire, due to objections from some quarters as to the amount of space which that object occupies in the automobile trunk. These devices range from collapsible emergency tires with limited service life to elaborate anti-puncture provisions in the regular road tires. Presumably, these devices would cost just about as much as the conventional spare.

It is my opinion that these proposals miss an important point. If a proper tire rotation program is followed, the fifth tire can be made to yield just as many useful road miles as the other four tires. This is not true of the proposed devices, as they add no useful road miles at all. Therefore, the investment in the conventional spare returns far more value than a comparable investment in any of these devices.

This consideration alone should insure the conventional spare its rightful, permanent, undisputed place in every trunk.

SAE's CEP News

COOPERATIVE ENGINEERING PROGRAM

Hansen, MacRae Join Automotive Council

Hansen

MERLIN HANSEN and **IVAN F. MACRAE** have been appointed members of the Technical Board's Automotive Council by Council Chairman George J. Huebner, Jr. As chief engineers in the tractor industry, both are well acquainted with standardization needs.

For the past three of his 30 years at John Deere, Hansen has supervised *all* activities connected with the design of new tractors and powerplants at the Research and Engineering Center. As an inventor and co-inventor, he holds 10 patents related to agricultural-type tractor units.

Hansen is a member of the SAE Tractor Technical Committee and served as chairman of its Agricultural Tractor Test Code Subcommittee from 1954 to 1957. In 1958 he was SAE Vice President representing the Tractor and Farm Machinery Activity.

MacRae

Since 1949, Ivan MacRae's work at Cockshutt Farm Equipment Ltd. has revolved around his duties as chief engineer of the Tractor Division. A graduate of Queens University, Kingston, Ontario, he was chairman of the Tractor Technical Committee in 1958. His understanding of standardization work comes from nine years as a member of this group.

At the moment, MacRae is also a member of the Tractor and Farm Machinery Activity Committee.

New ARP Offers Coiled Tubing Design

A CONVENIENT method of designing metal tube configurations (which provide for large relative motion between contiguous points in fluid systems) has been devised by members of Committee A-6, Aircraft and Missile Hydraulic and Pneumatic Systems and Equipment.

Approved by the Technical Board last month, the method has been designated ARP 584, Coiled Tubing. It covers design, analysis, fabrication, and installation of pressurized plain metal tubing.

The tubing is intended for use with actuators that oscillate about a pivot, areas of large structural deflection, such as reservoir installations, and areas of extreme environment where flexible hose could not survive.

Specific data are given for MIL-T-6845 tubing which ranges in diameter from ¼ to 1 inch, operates in 3000 psi hydraulic or pneumatic systems, and functions at temperatures falling into the following categories:

Type I	– 65 to 160 F
Type II	– 65 to 275 F
Type III	– 65 to 400 F
Type IV	– 65 to 600 F

ARP 584 will be available from SAE Headquarters sometime next month.

Accurate Measure of Decarburization Set

A UNIFORM method of measuring and evaluating decarburization of ferrous materials has been approved by the Technical Board as a new SAE Recommended Practice.

Scheduled to appear in the 1960 SAE Handbook, this Iron and Steel Technical Committee Division 30 report defines three types of decarburization and outlines three commonly used methods for measuring decarburization.

Publishing Policies Issued in New Guide

REPORT-WRITING chairmen and members of *ground vehicle* technical committees will soon have copies of a new eight-page booklet, "How to Prepare Good SAE Technical Reports."

For the first time, the Technical Board has released an up-to-date statement of basic publishing policies developed by the Publication Policy Committee.

The booklet contains four parts:

- A Chairman's Checklist.
- Definition and Classification of SAE Technical Reports.
- Legal Requirements for Technical Reports.
- Guide for the Preparation of Ground Vehicle Technical Committee Reports.

The recommendations contained in the booklet result from three years of investigation on the part of the Publication Policy Committee.

• Parts • Fittings • Components

Domain of General Standards

This is the third . . .

. . . in a series of four stories on the newly formed Councils for the SAE Technical Board. The Board's reorganization is described in full on pages 106 and 107 of the July issue.

EVERY ground, air, and space vehicle built in America today ultilizes *some* standard part, fitting, component, or process developed and maintained by the seven technical committees of the Technical Board's new General Standards Council.

This standardization work will continue under the new Technical Board structure. However, instead of reporting to the Board itself as was previous practice, the seven groups will report directly to the Council.

Top engineering executives from industries which use the committees' reports have been selected for Council membership. Serving with Chairman Milton J. Kittler, executive vice president, Holley Carburetor Co., are: E. C. Brown, chief engineer, Austin-Western Construction Equipment Division, Baldwin-Lima-Hamilton Corp.; G. E. Burks, vice president, research and engineering, Caterpillar Tractor Co.; Dr. C. R. Lewis, chief engineer, Basic Sciences Labs., Chrysler Corp.; Victor G. Raviolo, executive director, engineering staff, Ford Motor Company; and R. P. Trowbridge, director, Engineering Standards Section, General Motors Corporation.

During their terms of office, GSC members will review reports similar in content to those scheduled to appear in the 1960 SAE Handbook. Among these reports are:

Involute Splines, Serrations and Inspection

The first really comprehensive information to be developed on involute splines, serrations, and inspection is now available as an SAE Standard. Soon to be issued as an ASA standard, it will be used to represent the American view point on involute splines standardization within the International Standards Organization.

In revising this SAE Standard, the Parts and Fittings Committee added a completely new inspection section to round out the Standard. Use of this section will mean reduced production costs and more accurate quality control to parts manufacturers.

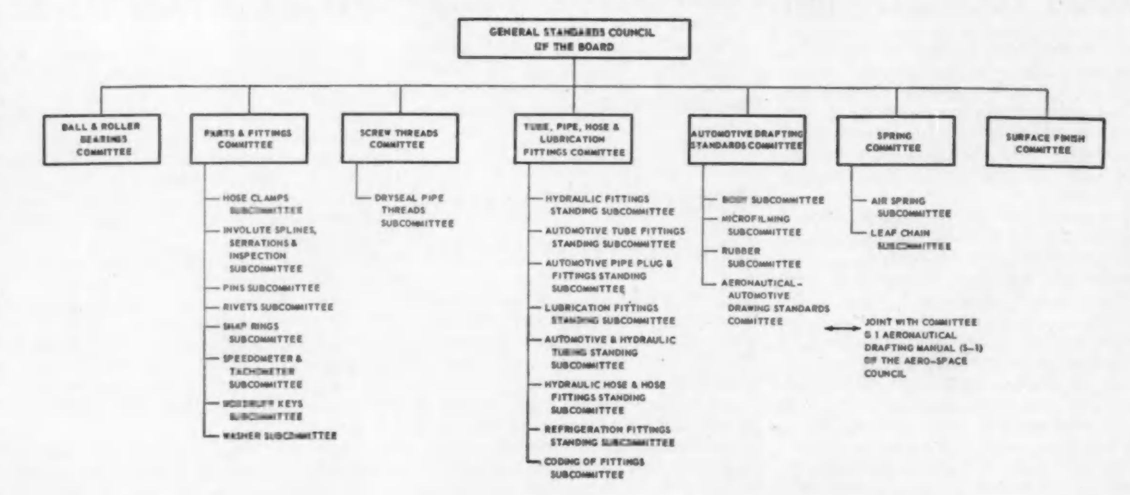
Rivets and Riveting

The new Rivets and Riveting Standard of the Parts and Fittings Committee provides general and dimensional data for flat, pan, button, truss, and countersunk heads as well as data on cooper's, tinner's and belt rivets. Also supplied are data on rivet design and assembly.

Automotive Tube Fittings

Serious production problems encountered with the use of cold-formed steel inverted flared tube nuts lead to the revision of the Automotive Tube Fittings Standard. To combat these problems, the Tube, Pipe, Hose and Lubri-

SAE GENERAL STANDARDS COUNCIL ORGANIZATION



• Processes

Council

cation Fittings Committee set up a special Subcommittee to study wrenching facilities, torque requirements, dimensioning and inspection. The Subcommittee's work brought about dimensional changes, plus the addition of a table on wrenching performance.

Dryseal Pipe Threads

The Screw Threads Committee has revised the Dryseal Pipe Threads Standard to include:

- Conversions from fractional dimensions on the chamfer and countersink diameters to decimals by use of a special formula.
- Revisions to the standard pipe thread tap tolerances.
- Changes to the designation of taper pipe threads for tap drills.
- Conversion of fractional dimensions of the other tables.

Ball and Roller Bearings

Increased use of very light ball bearings (1900 series) and shielded and sealed bearings lead to a revision of the Ball and Roller Bearing Standard. In addition, the Ball and Roller Bearing Committee up-dated sections covering front wheel bearings and tapered roller ball bearing tolerances.

Currently, the Committee is adding material on needle bearings as well as fan, pump, and rear wheel bearings.

Automotive and Hydraulic Pipe Fittings

To alleviate procurement difficulties encountered by users of fittings conforming to existing specifications, the Tube, Pipe, Hose and Lubrication Fittings Committee revised its Automotive and Hydraulic Pipe Fittings Standard. This revision represents an initial step in a long range program to bring the Standard's specifications into line with current manufacturing practices.

Automotive Drafting Standards

The first GSC circulation will consist of body drafting standards destined for inclusion in the Automotive Drafting Manual. These standards have been so prepared that, if approved, they will be ready for inclusion in the new Joint Aero-Auto Drafting Manual when it is issued after the first of the year.

. . . . Council Members

Chairman Kittler

Brown

Burks

Lewis

Raviolo

Trowbridge

BROAD industry experience is what the six members of the General Standards Council bring to their new SAE posts. With this as a backdrop, they will aid in directing the Council's seven technical committees.

CHAIRMAN MILTON J. KITTLER is executive vice president of Holley Carburetor Co. Prior to this affiliation which began in 1935, he did experimental work on carburetors and automatic chokes at the Bendix Products Division. Kittler's GSC duties will include sponsoring the Screw Threads Committee and the Parts and Fittings Committee at Council meetings.

A graduate of MIT, **E. C. BROWN** is chief engineer at Austin-Western Construction Equipment Division, an organization with which he has been associated for 28 years. Brown, who is currently a Technical Board member, has served on several SAE technical committees. As a GSC member, he will sponsor the Tube, Pipe, Hose, and Lubrication Fittings Committee.

G. E. BURKS, who is a former SAE Councilor and currently a member of the Technical Board, is vice president of Caterpillar Tractor's engineering and research. His broad knowledge of engine design stems from experience acquired as Caterpillar's chief engineer. Burks has been charged with sponsoring two Council groups: The Automotive Drafting Standards Committee and the Joint (with the Aero-Space Council) Aeronautical-Automotive Drawing Standards Committee.

As **DR. C. R. LEWIS** joins the Council, he is chief engineer at Chrysler's Basic Sciences Labs. The chairman of SAE's Nuclear Energy Advisory Committee and SAE's representative on the ASA Nuclear Standards Board, Dr. Lewis is also chairman of the Surface Finish Committee. He will sponsor Council's Spring Committee.

Recently named executive director of Ford's engineering staff, **VICTOR G. RAVIOLO** has been engaged in development work since he joined Ford in 1940. A current member of the CRC Board of Directors, Raviolo has been chairman of several CRC committees. He has also been a member of SAE's Fuels and Lubricants Technical Committee for 10 years.

ROY P. TROWBRIDGE, who directs General Motor's Engineering Standards Section, is well known for his work in ASA, SAE, ASME and other industry-sponsored engineering groups. The current chairman of the Parts and Fittings Committee, he will sponsor the Surface Finish Committee.

SAE MEMBERS

BOYD S. OBERLINK has been elected senior vice-president of Allis-Chalmers Mfg. Co. Oberlink joined Allis-Chalmers in 1934 as a service school trainee and became assistant supervisor of Allied Equipment Department in 1936. Subsequently he was made manager of Tractor Group's Washington, D. C. office, assistant construction machinery sales manager, and assistant to vice-president in charge of Tractor Group. He was named a vice-president in 1951, vice-president, Construction Machinery Division in 1955, and group vice-president in 1956. He was elected to the Board of Directors in 1957.

ALEX PETROVSKY has been appointed manager of the design engineering division of Lockheed Electronics and Avionics Division (LEAD). His previous experience includes two years as chief of product design with Convair Division, General Dynamics Corp., two years as chief of product engineering, Arma Division, American Bosch Arma Corp., and six years with W. L. Maxson Corp.

AIR COMMODORE F. R. BANKS (ret'd) has become director with engineering duties of Blackburn Group, Ltd., Blackburn Aircraft, Ltd., and Blackburn Engines, Ltd. in England. He was formerly director of the Bristol Aeroplane Co. and sales director of Bristol Siddeley Engines, Ltd.

H. FOLLETT HODGKINS, JR. is returning to his position as vice-president of Rollway Bearing Co., Inc., a subsidiary of Lipe-Rollway Corp., after a year's study of advanced management techniques and procedures under a Sloan fellowship at Massachusetts Institute of Technology. After serving White Sewing Co. as an engineer, Hodgkins joined Rollway Bearing in 1950 and became assistant general manager in 1957. He was elected vice-president early this year.

HAROLD E. CHURCHILL, president of Studebaker-Packard Corp., will speak on "Marketing in the Automotive Industry" at the Seventh Biennial Marketing Institute of the Minnesota Chapter of the American Marketing Association. The Institute will be held October 22 and 23 in Minneapolis. Churchill was SAE vice-president representing Passenger Car Activity in 1952.

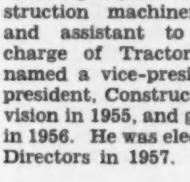
JAMES P. FALVEY has become deputy assistant secretary of defense with the Department of Defense. In this newly created post, Falvey will aid assistant defense secretary, Perkins McGuire in handling transportation, procurement and logistic matters for the nation's defense program. Falvey has been president of the Electric Auto-Lite Co. since 1954 and chairman of the company's board of directors since April, 1959.

LEONARD RAYMOND, SAE's president, and Socony-Mobil's chief automotive engineer for research, chose as his subject "Engineering Challenges to Automotive and Petroleum Research" in a talk he gave before Naval Reserve Petroleum Company 3-1 and Air Force Reserve Flight B Squadron 9210 on August 24. The meeting was held in the Texaco Auditorium in New York.

L. C. WOLCOTT has been appointed director of engineering at Packard Electric Division, General Motors Corp. Wolcott joined the former Packard Electric Co. in 1927 as time study engineer and subsequently became aviation sales engineer. He was named chief engineer in 1932.

J. ROBERT LAKIN has been appointed general sales manager of Packard Electric Division of General Motors Corp. Lakin joined General Motors in 1934 as an engineering trainee at Delco Products Division, and has served the company as sales engineer, procurement director, defense sales, manager of Delco Product's Zone Office and assistant general sales manager. In 1957 he became general sales manager of Moraine Products Division.

MARK E. RASPER succeeds J. Robert Lakin as general sales manager of Moraine Products Division, General Motors Corp. Previously he was sales manager of automotive assemblies at Moraine Products.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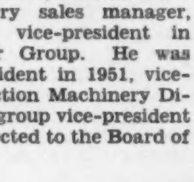
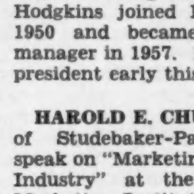
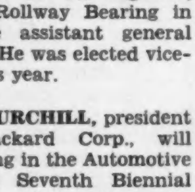
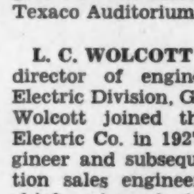
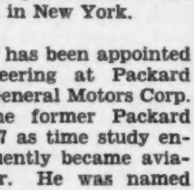

Petrovsky


Hodgkins


Falvey


Lakin


Wolcott

THOMAS B. RHINES has been made assistant engineering manager at Hamilton Standard Division of United Aircraft Corp. Rhines joined United Aircraft's research department in 1932 as an aeronautical engineer and transferred to Hamilton Standard as assistant engineer in 1939. He has served successively as chief production engineer, chief development engineer, assistant chief engineer and chief engineer.

HARVEY R. SMITH recently became executive vice-president, aeronautical at A. V. Roe Canada, Ltd. Previously he was vice-president and general manager with Dominion Steel & Coal Corp., Ltd.

VICTOR ALBERTSON, research engineer with Minneapolis-Moline Power Implement Co., recently patented the Viking Torq-Spin Ratchet Wrench. Albertson designed this new tool to provide utility in situations where normal handle swing is not possible. It is constructed to permit extra fast ratchet rotation by twisting the handle back and forth rapidly through a 90 deg. arc.

HARVEY C. CHRISTEN, director of quality control with Lockheed Aircraft Corp., has been made vice-chairman of the newly organized technical council of the Society for Nondestructive Testing.

HAMILTON MIGEL, vice-president in charge of research and engineering with Magnaflux Corp., will speak on "Penetrant Inspection" at an all day Educational Clinic scheduled by the Society for Nondestructive Testing. The clinic will be held November 6 as a part of the society's 19th Annual Convention.

ROBERT NELSEN, manager of technical publications with Aircraft Gas Turbine Division of General Electric Corp., will speak on "Writing in Modern Technology," at the Society for Nondestructive Testing's Educational Clinic.

LAWRENCE GENE SCOTT has joined General Electric Co. as specialist in model applications. In this position he will be concerned with controls and accessories system engineering for the J-79 engine. Formerly he was systems engineer with Allison Division, General Motors Corp.

CARROLL STOECKER has been appointed assistant manager of Aero Engineering Division, Garrett Corp. Stoecker joined Garrett in 1950 as sales engineer. He has also been branch office manager and eastern district manager. Prior to 1950 he was employed by Civil Aeronautics Administration, American Overseas Airlines, and American Airlines.

RICHARD J. NUFFER has become special Detroit representative for Electric Auto-Lite Co. Previously he was a sales engineer with the Anderson Co.

SURENDRAKUMAR P. PATEL has become research assistant in the mechanical engineering department of Pennsylvania State University. Patel is on an educational leave of absence from Caterpillar Tractor Co. where he was employed as design engineer. He is studying for the degree of Doctor of Philosophy in Mechanical Engineering.

EDWARD GRAY has become director of quality control with Chevrolet Motor Division of General Motors Corp. Gray joined Chevrolet five years ago, and directed the company's engineering activities at the General Motors Proving Ground for a year until being placed in charge of production engineering.

RALPH H. ISBRANDT, director of automotive engineering with American Motors Corp. and chairman of SAE Technical Board, is scheduled to speak on "The Vehicle in the Sixties" on October 21, at the Annual Safety Congress of the National Safety Council in Chicago.

BARRY EVANS has been appointed vice-president in charge of engineering and sales with Universal Hydraulics Division of J. H. Holan Corp. Formerly he was manager of parts and service with Hydreco Division of New York Air Brake Co.

ROBERT G. YEAMANS has been named assistant to manager of the F-108 Rapier Weapon System at Los Angeles division of North American Aviation, Inc. For the past six years Yeamans was senior representative for North American to FIAT in Turin, Italy, during production of Sabre Jets for NATO forces.

Ambassador to Belgium

Burden

WILLIAM ARMSTEAD MOALE BURDEN has become United States Ambassador to Belgium. He is a graduate of Harvard and took special courses in flying studies at Massachusetts Institute of Technology. Until 1932 he was in charge of analysis of aviation finances with Brown Bros., Harriman & Co. He served other companies in air research and development until World War II when he became vice-president of Defense Supplies Corp., a subsidiary of Reconstruction Finance Corp. From 1943 to 1947 Burden was assistant secretary of commerce for air. He became air consultant for Smith, Barney & Co. in 1947. From 1950 to 1952 he served as special assistant for research and development to the secretary of the Air Force. More recently he entered private industry as a senior partner in William A. M. Burden & Co. Burden is president of the Museum of Modern Art and a life trustee at Columbia University. He is a member of President Eisenhower's National Aeronautics and Space Council.

LAWRENCE R. DANIEL, JR. has joined the engineering department of the United Stated Naval Academy in Annapolis, Md. This position is in connection with the Academy's current program for improving its engineering curriculum. Daniel is on a one year leave of absence from the Louisiana Polytechnic Institute where he is a professor of mechanical engineering.

HERMAN L. COPLEN, JR. has become technical consultant with the Institute for Defense Analysis, ARPD/IDA at the Pentagon. Previously he was department head, systems and controls department with Aerojet-General Corp.

Continued

Henshaw

Reinders

Alstrom

Lambeck

Schrader

Manville

SAE MEMBERS

— continued —

ARTHUR F. BERNTHAL has been named managing director of Bundy Tubing Co.'s Research and Development Laboratories. Bernthal has served Bundy for over 25 years and most recently held the position of advertising and sales development manager.

ROBERT G. LeTOURNEAU, president of R. G. LeTourneau, Inc., is winner of the National Defense Transportation Association's annual award for aiding "the effectiveness of the transportation industry in support of national security." LeTourneau is being honored primarily for his company's development of the LeTourneal Electric Wheel.

HAROLD E. WELLS has become engineering manager of landing gear controls with National Water Lift Co., a Division of Cleveland Pneumatic Industries, Inc. Previously he was chief engineer of aircraft hydraulics with Bendix Products Division of Bendix Aviation Corp. Wells is a member of SAE 6 Hydraulic Pneumatic Committee and SAE-3A Connector and Seal Committee.

JAMES B. AUSTIN, vice-president of Research & Technology, U. S. Steel Corp., has become a director of the American Institute of Mining, Metallurgical, and Petroleum Engineers. Austin, who is a former president of American Society for Metals, will represent the Metallurgical Society.

RICHARD C. HENSHAW has been appointed manager of operations at Lord Manufacturing Company. He has served Lord since 1938 as drafting supervisor, design engineer, product engineer, chief product engineer, manager of product and sales engineering and manager of Engineering Division. In his new position he assumes over-all responsibility for activities in the Engineering, Manufacturing, and Marketing Divisions of the company.

GLENN D. REINDERS has been appointed diesel engineering sales manager for the Deutz Diesel Engine merchandising program recently announced by Chrysler Corp.'s Marine & Industrial Engine Division. Reinders has spent several months studying the Deutz engine both in the U. S. and in Western Germany and has served Chrysler in various engineering positions. Most recently he was project engineer with their Engineering Division.

ALBERT I. ALSTROM has been appointed manager of original equipment sales for Wico Electric Co., a Division of Globe-Union, Inc. Alstrom has served the company for 21 years and was most recently manager of Flywheel Magneto sales. Before joining the sales department, he served in the engineering department for 17 years.

CHARLES FROESCH, vice-president in charge of engineering with Eastern Air Lines, Inc., has become a member of the Engineering Advisory Council for University of Miami's School of Engineering. Froesch was SAE vice-president representing Air Transport Engineering in 1946.

RAY P. LAMBECK has been appointed engineering manager-major programs for Aero Hydraulic Division of Vickers, Inc. Lambeck has served the Hamilton Standard Division of Vickers for 20 years and was most recently chief development engineer.

ALAN R. SCHRADER has been appointed Supervising Marine Power Plant Development engineer, head of Reciprocating Engines Division, Mechanical Engineering Department at the U. S. Naval Engineering Experiment Station in Annapolis, Md. Prior to his appointment Schrader was alternate acting head of the division and head of its Engines Development Branch. He is a registered professional engineer in Md.

WALLACE C. MANVILLE has been appointed manager of the Akron, Ohio branch of Schrader Division, Scovill Mfg. Co. Manville joined Schrader in 1949 as sales engineer and has recently been in charge of sales at Akron.

GEORGE H. MICHAEL has become assistant sales manager of Construction Machinery Division with Allis-Chalmers Mfg. Co. His previous position was sales representative.

VICTOR T. CARBONE recently became general manager of the Western Division of Fairchild Controls Corp. Formerly he was sub-systems manager with Servomechanisms, Inc.

FREDERIC J. WATKINS has been appointed sales manager at the Harrison Radiator Division of General Motors Corp. Previously he was assistant sales manager.

continued on page 109

G M Executives Advance


Goad


Skinner


Osborn


Kyes

Organization changes in top echelons of General Motors Corp., including appointment of two new executive vice-presidents (bringing the total to four), involved the following SAE members: **Louis C. Goad, Sherrod E. Skinner, Cyrus R. Osborn,** and **Roger M. Kyes,** all members of GM's board of directors.

LOUIS C. GOAD, who continues as executive vice-president, will have jurisdiction over all of GM's general staff activities. These are distribution, engineering, manufacturing, personnel, process development, public relations, research and styling.

SHERROD E. SKINNER has been elected an executive vice-president succeeding Goad in charge of the automotive, body and assembly, and parts divisions. (GM Truck & Coach Division has been moved to the car divisions group.) Since 1951, Skinner has been vice-president in charge of the accessory group.

CYRUS R. OSBORN has been elected an executive vice-president and will have jurisdiction over the engine divisions, the Dayton Household Appliance and Electromotive group, and the Overseas and Canadian group. (The Electro-Motive, Cleveland Diesel and Diesel Equipment divisions, as well as GM Diesel, Ltd. have been moved from the engine group to the Dayton, Household Appliance and Electro-Motive group.)

ROGER M. KYES, who since 1954 has been vice-president in charge of the divisions which have been designated the Dayton, Household Appliance and GM Truck group, will assume new duties in charge of the accessory group.

SAE MEMBERS

— continued —

WILLIAM R. LEFEVRE, JR. has become manager of research with Fruehauf Trailer Co. Previously he was chief engineer with Freightliner Corp. Prior to that, he was research engineer with Boeing Airplane Co.

J. A. BAILEY, JR. has been named manager of hydraulic hose sales for Goodyear Tire & Rubber Co. Previously a member of Goodyear's Akron hose sales staff, he is now with the company's new hose plant at North Chicago, Ill.

WILLIAM H. MILLETT has been appointed an assistant director of the Technical Service Laboratory with Union Carbide Chemicals Co. Formerly Millett was technical consultant to the New Chemicals Department, Union Carbide.

WILLIAM J. MILLER has retired as equipment engineer for Washington State Highway Department. Miller began his career in the automotive industry with General Vehicle Co., and subsequently joined Edison Storage Battery Co. as branch manger. In 1917, he became transportation engineer with White Motor Co. and then served them as branch manager at Harrisburg, Pa., wholesale manager at Boston, and district manager at Hartford, Conn. In 1938 he joined General Motors Corp., and at the beginning of World War II became head of maintenance in the Seattle Office of Defense Transportation. Subsequently he became automotive specialist for the Pacific Northwest and Alaska with the War Production Board. Following the war, he was given charge of war surplus disposal. In 1949 he joined the Highway Department. Miller plans to reenter private industry.

D. O. SMITH is now resident product engineer with Chevrolet Motor Division, General Motors Corp. Formerly he was senior contact engineer with the Chevrolet Division. Smith was 1958–59 secretary for SAE Buffalo Section.

continued

Miller

Smith

SAE MEMBERS

— continued —

EDWIN B. WATSON has been named chief engineer of the Diesel department at Scintilla Division of Bendix Aviation Corp. Since 1947 Watson had been associate professor of Mechanical Engineering at Cornell University. Since 1950 he has served as a consultant to American LaFrance Corp., Thompson-Ramo-Wooldridge Corp., Seneca Grape Juice Corp., and the New York State Department of Education.

O. T. FLEIG has been appointed director of maintenance scheduling and planning at American Airlines' Jet Maintenance Engineering Center. Previously he was director of turbine aircraft planning at the Jet Center.

ANTHONY DELTUFO, formerly equipment engineer with Socony Mobil Oil Co. de Venezuela, is now chief equipment engineer with Colombian Petroleum Co.

JAMES A. LEAKE has been appointed sales manager of Rockwell-Standard Corp., Stamping Division. Leake, who has had more than 20 years manufacturing and sales experience, was previously secretary and sales engineer; Leake Engineering Co.

JOHN M. SIMONETTI has become designer A with Boeing Airplane Co., plant 2. Formerly he was senior project engineer with Kett Technical Center, a subsidiary of U. S. Industries, Inc.

RICHARD F. MULLIKEN has become project manager at Thiokol Chemical Corp. Previously he was senior project engineer with Fairchild Engine Division, Fairchild Engine and Airplane Corp.

HEINZ HANAU has become director of engineering and research with Industrial Tectonics, Inc. Formerly he was supervisor of aircraft products with New Departure Division of General Motors Corp.

JOHN B. BAKER recently became chief engineer with International Division, Timken Roller Bearing Co. Baker joined Timken Roller Bearing in 1925 as industrial sales engineer. Prior to his recent appointment he was chief products engineer.

ERNEST A. CHARLEBOIS, previously owner of San Diego Auto Auction, is now owner of The Wagon Station of East San Diego. The new company specializes in the retail sales of station wagons.

PAUL T. HUGHES has been named director of maintenance with Steffke Freight Co. Previously he was with Burlington Truck Lines as superintendent of maintenance.

GUNNAR PALMGREN plans to retire as vice-president of SKF Industries, Inc. after nearly 40 years service. He will serve as vice-president and special consultant to the president through the end of the year.

RAYMON W. HOWELL has become general manager of Equipment Steel Products Division of Union Asbestos & Rubber Co. Formerly he was plant manager with Highway Trailer Co.

HAROLD H. WARDEN has joined Lockheed Aircraft Corp.'s Georgia Division as Hercules commercial sales manager. Previously he was commercial sales manager with Link Aviation, Inc.

CHARLES F. GREBE, JR. recently retired as plant superintendent with Milwaukee Die Casting Co., after serving the company for 43 years. Grebe started in the machine shop, and subsequently he became foreman of the bearing department. Later, when the company gave up the service end of their business, he became superintendent of the entire shop, devoting full time to supervising the making of die castings.

RICHARD S. WEISS, formerly chief sales engineer, has become chief technical engineer with Avica Corp.

R. C. PUTNAM has become quality engineer with Aero Division of Rolls-Royce, Ltd. Previously he was design engineer with Orenda Engines, Ltd.

WILLIAM MILTON MEYER has become specialist with General Electric Co. in connection with their T-58 Land and Marine Project, SAED. Previously Meyer was assistant to director of research with Locomotive Development Committee BCR, Inc.

DANIEL STERN has become vibration and stress analysis engineer with General Electric Co. Previously he was with the Department of the Navy as mechanical engineer at the Naval Ordnance Laboratory in Silver Spring, Md.

continued

Baker

Charlebois

SAE MEMBERS

— continued —

WALTER M. EVANS has become propulsion systems staff engineer with Georgia Division of Lockheed Aircraft Corp. Formerly he was project engineer with Flight Refueling Inc.

DONALD E. RIGGS, formerly division automotive engineer with Shell Oil Co., is now sales engineer with Spaulding Fibre Co., Inc.

LAURENCE M. GOODRIDGE, previously patent counsel with Carter Carburetor Division of ACF Industries, Inc., is now associated with Sutherland, Polster & Taylor in a similar capacity.

NED A. BANIA, formerly sales engineer with Asbestos Mfg. Co., has become owner of Ned Bania & Associates.

T. E. BOKEMEIER has become outside salesman with Ekman & Co. Auto Part, Inc. Previously he was director of placement service with Tractor Training Service. He has served in that capacity for the past 12 years and was vice-president in charge of resident training program for three years of that time. He has held the positions of treasurer, secretary and chairman of SAE Oregon Section and is presently membership committee chairman.

ARDEN C. DEGNER is now design engineer with Bucyrus-Erie Co. Formerly he was employed by Fairbanks, Morse & Co.

FRANK H. LEMONS, previously compounder with Grizzly Mfg. Division, is now development engineer with Asbestos Mfg. Co.

S. O. WAHAMAKI has been appointed chief design engineer at the Kenosha plant of American Motors Corp. Previously he was staff design engineer with American Motors.

F. R. KISHLINE, formerly assistant product development engineer with American Motors Corp., is now staff technical engineer at the Kenosha plant.

T. M. LAWLER, JR. has become assistant development engineer at the Kenosha plant, American Motors Corp. His previous position was project engineer.

S. V. PUIDOKAS, formerly a project engineer, has become chief project engineer, American Motors Corp.

MARSHALL DEAN KLINGER, formerly automobile engineer with Sinclair Refining Co., has become supervisor of consumer sales with Sinclair.

continued

SAE MEMBERS

— continued —

DAVID L. RAYMOND has become program planning director with Cleveland Pneumatic Industries, Inc. Previously he was chief engineer with Cleveland Trencher Co.

DONALD ARTHUR THORNLEY has become resident engineer with Chrysler Corp. Previously he was research engineer with Caterpillar Tractor Co.

PETER J. STELMAT, formerly engine maintenance and overhaul instructor with Pratt & Whitney Aircraft Division, United Aircraft Corp., has become technical representative with Pratt & Whitney Aircraft.

JOHN J. DEVLIN has become supervisor, gas turbine systems, sales, with AiResearch Mfg. Co., Division of Garrett Corp. Formerly he was sales representative with Solar Aircraft Co. In 1948 he was secretary of SAE Tri-State College Chapter.

PHILIP B. FREEMAN has become an engineer in connection with the T-38 flight test program at General Electric Co.'s Small Aircraft Engine Department. Previously Freeman was supervisor of flight test at Fairchild Engine Division, Fairchild Engine and Airplane Corp.

EDWARD J. SYDOR has been appointed chief engineer with Cycleweld Chemical Products Division of Chrysler Corp. Previously he was senior research scientist in the Central Engineering Division.

Obituaries

JACK BARNES . . . (M'43) . . . truck specialist, Hatfield Motors, Inc. . . . died June 18 . . . born 1905.

HANS BOHUSLAV . . . (M'36) . . . technical consultant . . . died June 8 . . . born 1902.

RAY EDGAR CARSON . . . (M'23) . . . head, department of mechanical design, Eli Lilly & Co. . . . died May 13 . . . born 1899.

L. T. GIRDLER . . . (M'21) . . . president, Standard Automotive Parts Co. . . . died April 13 . . . born 1880.

DR. RAYMOND HENRY HOBROCK . . . (M'39) . . . retired vice-president in charge of research for Bundy Tubing Co. . . . died September 10 . . . born 1900.

STEPHEN JENCICK . . . (M'08) . . . retired president of Climax Motor Products Co. of Cleveland and Climax Motor Parts Co. of Chagrin Falls, Ohio . . . died June 3 . . . born 1879 . . . credited with design improvements in submarine propulsion engines for U. S. Navy at turn of century . . . was a pioneer member of SAE.

DARYL F. LEMAUX . . . (M'50) . . . assistant experimental engineer, Truck & Coach Division, General Motors Corp. . . . died August 6 . . . born 1902.

WILBUR RAYMOND MOREHOUSE . . . (M'29) . . . plant engineer, Morehouse Baking Co. . . . died July 9 . . . born 1889.

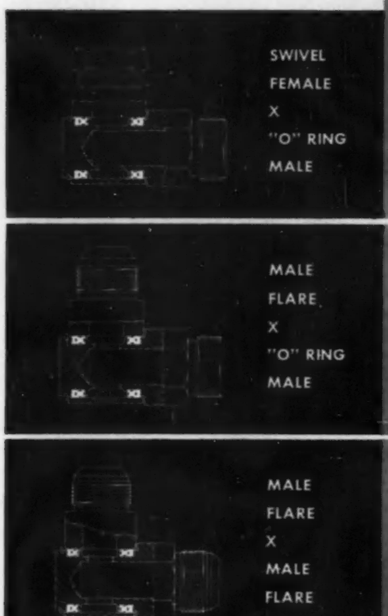
CHARLES HERMAN REYNOLDS . . . (M'41) . . . retired vice-president and former member of board of directors, The Sheffield Corp., a subsidiary of Bendix Aviation Corp. . . . died August 31 . . . born 1891.

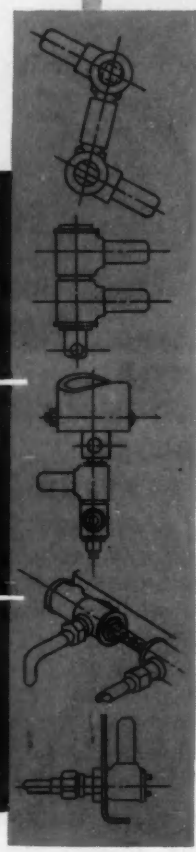
HAROLD S. VANCE . . . (M'27) . . . member of Atomic Energy Commission . . . former chairman of executive committee of Studebaker-Packard Corp. . . . died August 31 . . . born 1890.

Eastman offers INDUSTRIAL SWIVEL CONNECTOR

to eliminate hydraulic hose failure under severe flexing

Licensed Under
Pat. No. 2481404





STANDARD SIZES AND COMBINATIONS AVAILABLE

LOW TORQUE—Freedom from friction, even under high pressure.

WIDE RANGE—Operating pressures up to 5000 PSI. Trouble-free operation through wide temperature range.

ROTATION—Full 360° for all manifolds.

SIZES—Steel, plated for corrosion protection—½" thru 1½".

If you have been designing "around" metal swivel joints because of high cost, EASTMAN now offers an economical swivel connector for industrial use—precision engineered to assure adequate freedom of motion—proved under the most rigid government requirements.

Unique design assures "balanced" flow of hydraulic fluid at required pressure—at any angle. Fluid pressure is also balanced by a ***double seal*** assembly at each end of stem. Pressure-Balance assures equal internal pressure, causing the body to float about the stem, free of end load and friction.

Eastman Swivel connectors will make your flexing installations the most reliable link in your Hydraulic Assembly.

APPLICATIONS:

For use on Cranes, Loaders, Earth Moving Equipment, Hydraulic Presses, Shears, etc.—wherever unusual flexing and exposure may shorten hose life or cause premature failure and frequent replacement.

ECONOMY:

Permits use of shorter hose lengths since less hose allowance is needed for complete extension. Shorter lengths of longer lasting, multiple spiral wire high pressure hose may be used, since Swivel Connector absorbs flexing motion.

ADAPTABILITY:

Body of Connector available with any combination of ends. Now available in types and sizes shown at left. Various combinations of stems can be interchanged with any body style.

WRITE, WIRE or CALL about Eastman Swivel Connector Opportunities in Your Line.

Eastman
first in the field
MANUFACTURING COMPANY
Dept. SAE-10, **MANITOWOC, WISCONSIN**

SAFEGUARDING AMERICA'S LIFELINES OF MOBILE POWER

New Members Qualified

These applicants qualified for admission to the Society between August 10, 1959 and September 10, 1959. Grades of membership are: (M) Member; (A) Associate; (J) Junior.

Alberta Group

David Laurence Palmer (A).

Buffalo Section

Theo B. Case (A).

Central Illinois Section

Raymond E. Binkele (M), Willard Lee Birge (J), Joseph E. Bury (M), Robert Dale Janosov (J), George Johan Maat (A), Norman Thomas Mattson (J), John R. McMichael, Jr. (J), Gene L. Stear (J), Noel Delbert Wiggins (A).

Chicago Section

Richard T. Bennett (J), James Stewart Bray (J), Irving W. Doucet (J), I. C. Friedman (A), Antoni J. Gorka (M), William P. Hendershot (A), Louis W. Holtman (M), Gordon L. Kibbey (A), Lawrence Dale LaCroix (M), Richard K. Nelson (M), James F. Prindiville (M).

Cleveland Section

Jack A. Davisson (J), Adolph A. Karrasch (M), Eugene Donald Williams (M).

Detroit Section

Philip Robert Austin (J), Anthony James Burgess (M), Benjamin E. Derrick (A), Robert M. Doll (J), J. B. Dupuis (A), Fremont Fisher (A), Ray E. Goeboro (A), Herbert B. Hindin (M), William Irvin Mittel (J), Leon H. Nies (A), Fred G. Oblinger (M), Ronald R. Perkey (A), Duane C. Perry (M), Arthur C. Pope (J), James Donald Shircliff (A), Maurice P. Whalley, Jr. (M), Earl Chester White (M), Raymond J. Winiarski (J), Nickolas P. Yonutas (A).

Fort Wayne Section

Richard H. Cook (M), Bernard J. Lehman, II (J).

Hawaii Section

Mahlon P. Woodward (A).

Indiana Section

Arliss Johnson Gorby (J), Hugo V. Kojola (M), Robert H. Roth (A), Willard C. Shaw (A).

Kansas City Section

James E. Garrison (A).

Metropolitan Section

Howard Lawrence Chane (J), Richard H. Coulton, Jr. (M), Anthony V. Frasca (A), Edmund Sennert (A), Shepherd Sikes (A) William M. J. Wiehl (M).

Mid-Continent Section

William T. O'Shields (M).

Mid-Michigan Section

William Laurence Compton, Jr. (J), Ralph E. Frick (M), Jack F. Leach, Sr. (A), Charles E. Schalla (A), Gunter Wickel (M).

Milwaukee Section

John W. Boda (J), Richard Jasensky (M), Glenn J. LaZotte (A).

New England Section

Robert F. Dunlop (A), Russell S. Rockafellow (M).

Northern California Section

James L. Smartt (A).

Northwest Section

W. A. Call (M), William F. Hetrick

continued

Exclusive design of Sealed Power stainless steel oil rings ends piston groove depth variation problems

Sealed Power 3-piece stainless steel oil rings eliminate groove depth variation problems for two reasons: new end abutment design (see enlargement); and new material (stainless steel).

The cut-away view of the stainless steel oil ring in the piston groove shows how this expander rides independently of the bottom of the groove. The combination of end abutment design—and stainless steel, which has negligible tension loss at engine operating temperatures—means better oil control for the life of the ring. The chrome-plated side rails have the desired initial contact with the cylinder wall—maintain this desired contact where rings with ordinary expanders lose it because of high tension drop-off.

The properly engineered number of spring tension points and sturdy shoulders hold the side rails snugly against the cylinder wall and the sides of the groove. Result? Correct cylinder wall lubrication; no passage of oil around the back of the ring.

OTHER KEY FEATURES:

- Stops oil consumption
- Stops smoking even under high vacuum operation
- Side-sealing
- Quick seating
- Chrome-plated for long life
- Easy to install

SEALED POWER CORPORATION, MUSKEGON, MICHIGAN • ST. JOHNS, MICHIGAN • ROCHESTER, INDIANA • STRATFORD, ONTARIO
DETROIT OFFICE • 7-236 GENERAL MOTORS BUILDING • PHONE TRINITY 1-3440

Sealed Power Piston Rings PISTONS CYLINDER SLEEVES

Leading Manufacturer of Automotive and Industrial Piston Rings Since 1911
Largest Producers of Sealing Rings for Automatic Transmissions and Power Steering Units

New Members Qualified

. . . continued

(A), John D. Morell (J), Roy E. Rodman (A), John C. Watson, Jr. (J).

Ontario Section

W. A. Paterson (A), Paul DaFoe Stata (J).

Philadelphia Section

Luke L. Stager (M).

Pittsburgh Section

M. W. Marshall (A).

St. Louis Section

Edwin A. Boeck, Jr. (A).

Salt Lake Group

Dieter K. Schmidt (J).

San Diego Section

Harro Zuest (J).

South Texas Group

Joel D. Watkins (J).

Southern California Section

William J. Baldwin (M), Reginald B. Bland (M), Thomas Francis Dixon (M), Frank D. Hartzell (M), Daniel S. Izzo (M), Douglas M. Longyear (M), Jack Weston KcKeehan (M), Robert Frank Preston (J), Charles M. Savage, Jr. (J), James C. Walshe (A).

Southern New England Section

Edward Lacey (M), William Finley Laverty (J).

Syracuse Section

Robert J. Heinzman (M).

Texas Gulf Coast Section

James E. Sadler (J).

Virginia Section

Byrd F. Shrader (M).

Wichita Section

Charles F. Hill (M), Daniel Ernest Lamaster (J).

Outside Section Territory

Robert V. Brink (J), Ernest Edwin Robertson (A), Carrol J. Warrell (M).

Foreign

Peter Kenneth Leneve Arnold (M), New Zealand; Jawahir Lal Dhar (J), India; Piet Olyslager (M), Holland; Brian Grenville Stacey (M), England.

Applications Received

The applications for membership received between August 10, 1959 and September 10, 1959 are listed below.

Alberta Group

Lewis Mark John Townsend

Atlanta Section

David J. Shaw

Baltimore Section

Russell L. Swartz, Jr.

Buffalo Section

Anthony J. Carlisi

Central Illinois Section

Ralph Eugene Denning, George W. Dudley, Gene Alan Pfotenhauer

continued

Aluminum trim packages run $8.00 to $14.00 less per car than the

Jacobs, Wilbur W. Jarvis, Jr., Edward Colorado Group

Applications Received

continued

Chicago Section

Robert J. Askevold, Don Carter, Thomas Joseph Culhane, Jr., Robert F. Davis, Louis G. DeGrace, Jr., Chester A. Dubowski, Paul Charles Erickson, Richard Earl Fiser, Robert Otis Flint, Richard C. Hayes, Gus H. Ilika, Donald Jacobs, Wilbur W. Jarvis, Jr., Edward P. Migit, James Dennis Neff, Jack M. Richards, Robert Mark Shane, David Westley Spoonamore, Maurice Van Dierendonck

Cincinnati Section

William A. Grissom, William E. Mayeros, Wilton F. Melhorn

Cleveland Section

Ralph Paul Alberts, L. J. Campbell, Malcolm Charles Daykin, Adrian P. Fioretti, Thomas Matthew Franklin, Rudolf Hans Schleicher, Robert Sergeson, Jr., James Edward Sheffield

Colorado Group

Lee Edward Anderson

Dayton Section

Bernard S. Mehall, Jr., Walter Stanley, Robert A. Todd, Richard Leon Ummel

Detroit Section

Burlin H. Ackles, Jr., David D. Anderson, Ivan Angeloff, John A. Betti, Richard Peter Bialek, Charles C. Bingaman, John E. Blomquist, Charles A. Brethen, Jr., William A. Burmeister, Jack S. Clifford, John R. Costello, Robert E. Delderfield, E. E. T. Dulfer, Raymond J. Fiedler, Richard Thomas Geggie, Albert J. Gonas, John H. Greening, Paul Richard Henry, Martin J. Hermanns, Richard A. Higginbottom, Arthur Luther Jaeger, Jr., Frederick W. Krey, Carl Lessen, W. B. Liggett, Clarence D. Lutton, Jr., Leo Robert Marcy, Donald Richard Mentlikowski, Robert T. B. Peirce, Alfred Frank Poy, Donald P. Pratt, Kenneth John Price, Gilbert F. Richards, Robert E. Spencer, John W. Steggall, George Steinberger, Charles Loren Sutherland, Mike A. Todosciuk, Schuyler Yates, Harold Bruce Meyer

Fort Wayne Section

John Raymond Duff, John J. Renner, Barrie Lee Wilson

Hawaii Section

Thomas A. Koch, Richard S. Uyemura

Indiana Section

Jack M. Geller, R. Gene McCullum

Kansas City Section

Gilbert W. Gaarder, James E. Hestand

Metropolitan Section

Clifford G. Banks, Angelo William Castellon, Robert H. Foglietta, Dezi Joseph Folenta, Karl Eric Ludvigsen, Kenneth L. Myers, Thomas A. Pakenham, Morton D. Schliefer, Lawrence M. Tucker, Edmond Yang

Mid-Continent Section

John P. Graham

Mid-Michigan Section

Elmer E. Braun, James E. Cohen, Joseph E. Godfrey, Bernard A. Kruszka, Joseph J. McAnallen, Bernard I. Miller, Frederick N. Mueller, Juras D. Philo, Donald F. Richter

Milwaukee Section

Donald J. Berchem, Kyle Roger Ericson, Gilbert C. Hahn, Levi E. Haigh, Raymond G. Knudsen, Robert G. Schindler

Montreal Section

Maurice Morin, Gilles Poitras, George William Todd

continued


OUR SPECIALTY
...better rings from better metals
What's behind a better ring? For one thing, a superior metal like electric-furnace PHOSALLOY—another McQuay-Norris exclusive that gives rings unusual toughness and tension-retaining qualities!...Let one of our sales engineers give you the whole story. Let him show you how we work with original equipment designers to get the results they must have. Call us next time you have a piston ring problem.
McQUAY-NORRIS
MANUFACTURING CO., ST. LOUIS • TORONTO
Largest Producer of small rings in the automotive industry.

Applications Received

continued

New England Section

John P. Attiani, Robert K. Horne, Alfred J. Michaud

Northern California Section

William A. Brummond, Philip Dimitriou, Andy Oberta, Paul L. Markowitz, Richard A. Seward, Leo S. Takeuchi, Edwin Dale Thompson, Normand Earl Westmore, Warren R. Whitehead

Northwest Section

Milo Duncan Bell, Peter A. Esbensen, Robert Joseph Norman Rousseau, Charles Joseph Woodruff

Ontario Section

John Douglas Franks, Donald M. Turnbull, Robert V. Yohe

Philadelphia Section

William A. Conway, Lawrence Lazarow, Frederick William Pyle, Raymond Best Schreckengast, James E. Sinderson

Pittsburgh Section

William J. Collins

Rockford-Beloit Section

Jere G. Castor, Donald F. Kowalick, Van Tassell Stonehocker

Salt Lake Group

Phillip Clyde Petty, Robert Jay Wheelwright

San Diego Section

Thomas Allen Drew, Robert Alva Farnsworth

Southern California Section

Henry R. Blecha, Ronald Orville Byram, William Robert Dildine, John E. Fagan, Dale Irving Fritz, William J. Galli, Glen Ellmore Grant, Carl Holman Grover, Robert F. Hurt, Neubar Kamalian, Thomas J. Madden, Donald S. McCulloch, Ted Robert Melsheimer, Frederick W. Miller III, Jack R. Potts, J. Charles Preble, Paul Vernon Steffen, Douglas A. Tummond, Robert Eugene Wright

Southern New England Section

David W. Bott

Syracuse Section

Ronald W. French, Ricardo H. Vergara, Arnold S. Brooker

Texas Section

Samuel Dean Carpenter

Texas Gulf Coast Section

Wayne H. Herndon

Virginia Section

James Michael Fish

Washington Section

James H. Drum, Clifton G. Wrestler, Jr.

Wichita Section

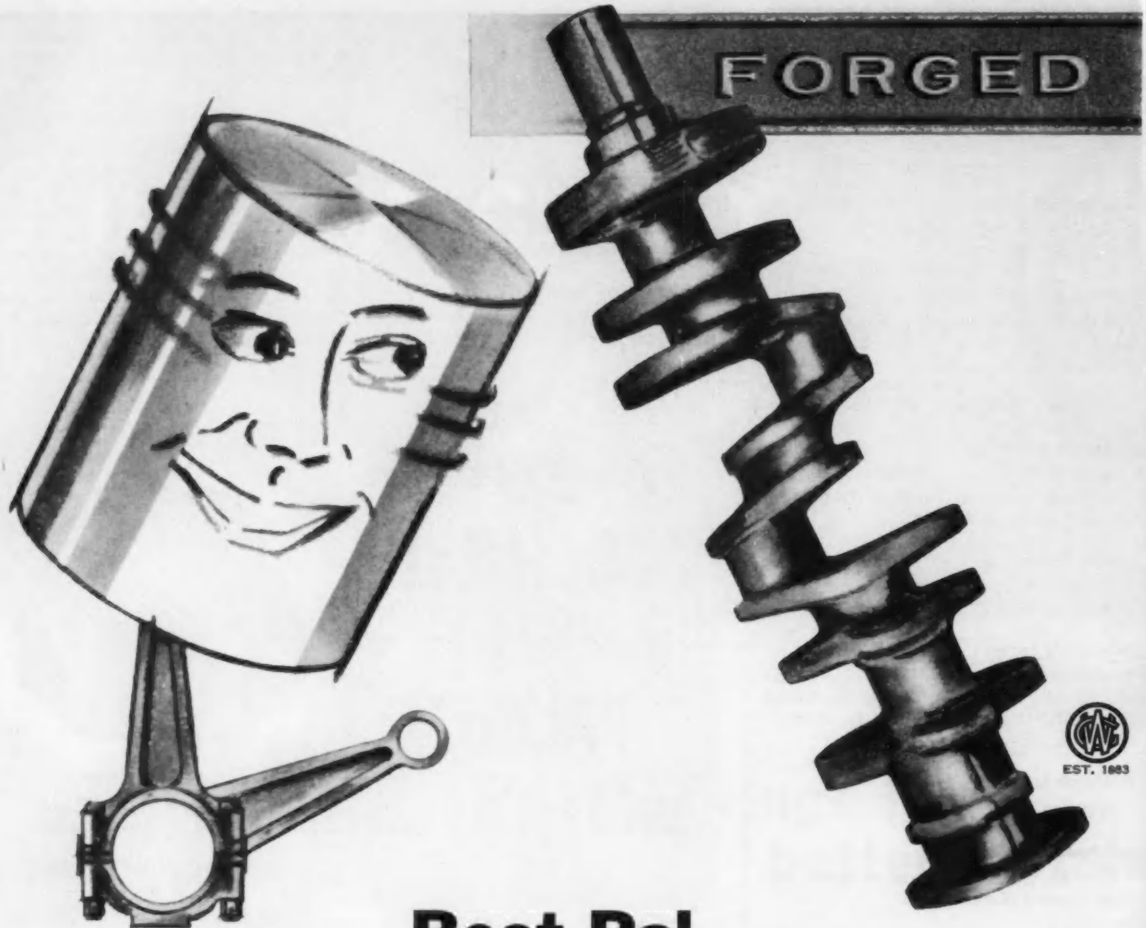
Donald J. Ahrens, Jack R. Hodges, Loyal G. LaPlante, Kenneth L. Stuckenschneider, Charles F. Tate

Outside of Section Territory

M. C. Burr, William James Cooke, James Peter Doering, Lawrence J. Fetter, Roger L. Fuetter, Garth O. Hall, Joel H. Leet, Norman C. Nitschke, A. W. Oehler, John P. O'Reilly, G. G. Pins, J. E. Richert

Foreign

Salvador Arena, Sao Paulo, Brazil; Gerhard Benteler, Germany; Carl O. Gabrielson, Sweden; Lt. Col. Hans Michael Joseph Jensen, Singapore, Maylaya; Charles Evelyn Jones, Australia; Alexander Mundlak, Venezuela; Mohammad Afzal Niazi, West Pakistan; M.J.F. Claude Pilot, Mauritius, India Ocean; Jon Prietz, Norway; Luigi Zandona, Italy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Briefs of SAE PAPERS

continued from page 6

ing Variables on Engine Wear, B. A. ROBBINS, P. L. PINOTTI, D. R. JONES. Paper No. 72U. Research program carried out jointly by General Metals Corp., Standard Oil Co., and California Research Corp., to study effects of engine speed, load, jacket water temperature, fuel temperature; results obtained using chromium plated piston rings, distillate and two residual fuels.

Rating Transmissions from Highway Requirements and Vehicle Specifications, F. C. MELDOLA. Paper No. 76U. Variables listed on which rating of truck transmission depends; use of gradeability formula; gradeabilities in various gear ratios can be calculated for any vehicle specification; by correlating them with highway requirement probability curve, percent of time in each ratio can be obtained; curves.

Development of Two New Allis-Chalmers Diesel Engines, H. L. WITTEK. Paper No. 70T. Naturally aspirated and turbocharged direct injection engine, "16000" and "21000", intended specifically to power certain crawler and wheel type vehicles; combustion chamber, initial swirl, and valve timing; performance data and other test results.

Hi Fi Dynamometer Testing by Tape Programming, V. C. VANDERBILT, Jr., C. L. ZIMMER. Paper No. 69V. Programmed test employed at Perfect Circle Corp., Hagerstown, Ind., to determine service oil economy or engine wear; block diagram of tape recording system; servo and electronic systems.

Eight Lane Dynamometer Highway, O. G. LEWIS, R. R. RISHER, Jr., J. A. WILSON. Paper No. 69U. Automatic road load dynamometer system, and outdoor mileage accumulation dynamometer test facility, designed to handle test car fleet operation, built by Esso Research and Engineering Co., to determine whether automotive engine octane requirement determinations obtained on road could be reproduced accurately on chassis dynamometer; evaluation of results.

Cooling Systems, C. S. HORRIS. Paper No. 77T. Problems peculiar to construction equipment such as radiator core plugging occurring in tractors engaged in land clearing, logging etc; various methods of keeping debris out of core by means of filtering, screening, fans etc; future efforts center around unit radiator and fan package containing small dense core and efficient, un-

continued on page 131

Briefs of SAE PAPERS

continued from page 129

obstructed fan, whole unit being protected by air filtering system.

Engine Cooling and Automobile Styling, D. H. McPHERSON, P. J. KING. Paper No. 77X. Functions of passenger car cooling system; cooling indexes for three basic Chevrolet engines and establishment of idle cooling index; recent Chevrolet styling and its effect on cooling; future possibilities toward development of fans of improved efficiency and lower noise level.

Coolant Circulation as It Affects Engine Cooling, J. C. MILLER. Paper No. 77U. Fundamentals of cooling system including circulation, radiation and air flow, which have to be considered to correct cooling troubles on diesel or gasoline engines; four basic requirements of circulating system; diagrams.

Radiators — and Then Deaeration, R. G. JENSEN. Paper No. 77V. Major variations from basic design conditions that affect cooling capacity of engine cooling system are theoretical vs actual air flow; maldistribution of water and air; entering air temperature different than ambient air; plugging or fouling on air or water side, and air entrainment; examination of causes that contribute to aeration and inadequate cooling.

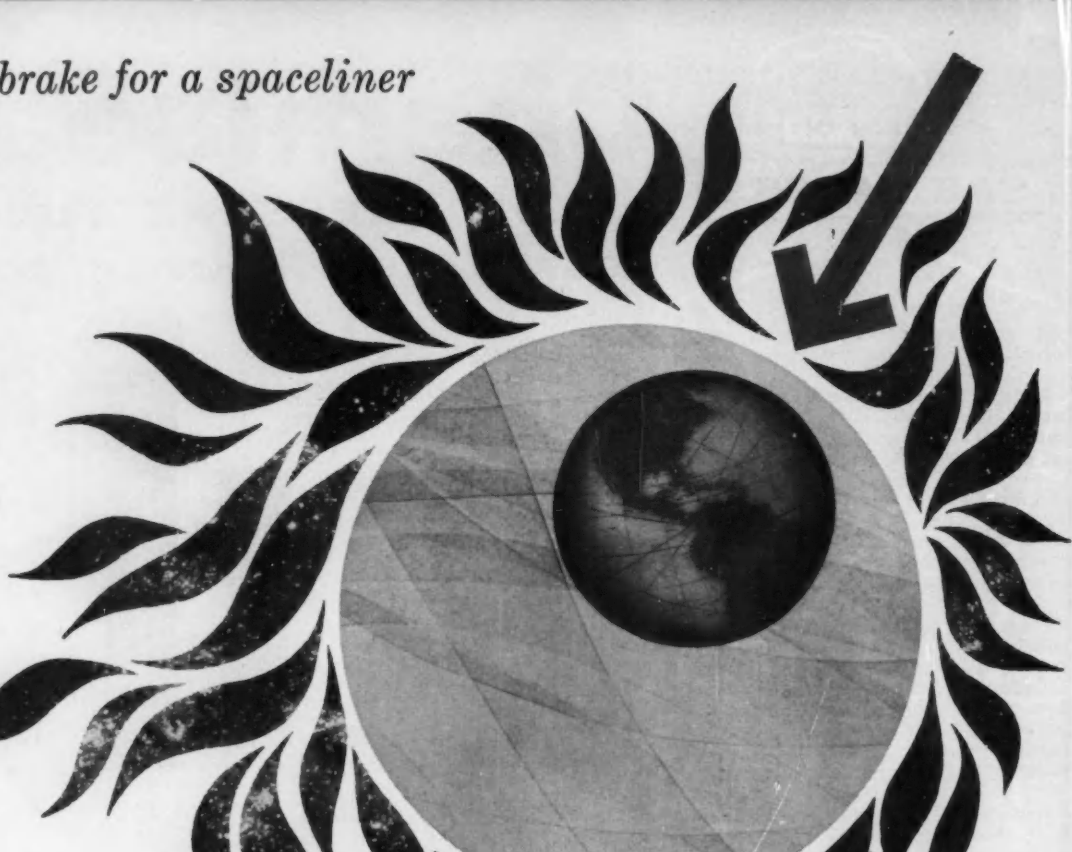
Let's Reappraise Function of Fan, T. J. WEIR. Paper No. 77W. Cooling systems in automobile engines are designed for maximum temperature day with maximum engine power output; results expected when conditions other than maximum occur; tests show that while cooling system must be provided for maximum conditions, these occur rarely and fuel is wasted driving fan at speeds in excess of that required; more attention should be paid to problem of overcooling.

Spare Tire Substitutes, R. P. POWERS. Paper No. 79T. Investigation of substitutes requiring less space, easier storage, yet performing all functions of present spares; proposed types divided into self contained tires, and substitutes whose use permits flat tire to remain in place; devices which require complete removal of flat tire and are adaptable to existing tire and wheel assemblies; devices applicable to new type of wheel which permits easy removal of flat tire; "Taper Lock" application.

Progress Report of Spare Tire Elimi-

continued on page 133

Air brake for a spaceliner



The earth's atmosphere, one of the biggest obstacles to getting into outer space, can be one of our biggest assets coming back. At Douglas we are investigating how we can use its braking effects on rockets returning from deep space trips at far faster than ICBM speeds. Success will allow us to increase payloads by reducing the weight of soft landing systems. This technique also will aid us in pinpointing landing areas. Current reports show real progress. Douglas is engaged in intensive research on every aspect of space planning, from environmental conditions on other planets to the destroyer-sized space ships necessary to get there. We invite qualified engineers and scientists to join us. Some of our immediate needs are listed in the column on the facing page. Please read it.

Arthur Shef, Chief, Advanced Design Section, Missiles and Space Systems, irons out a problem with Arthur E. Raymond, Senior Engineering Vice President of DOUGLAS

MISSILE SYSTEMS ■ SPACE SYSTEMS ■ MILITARY AIRCRAFT ■ JETLINERS ■ CARGO TRANSPORTS ■ AIRCOMB ■ GROUND-HANDLING EQUIPMENT

Briefs of SAE PAPERS

continued from page 131

nation, R. E. DAVIES. Paper No. 79U. Approach taken by B. F. Goodrich Tire Co.; type of tire selected for spare tire elimination must be capable of service after being punctured; following tire designs proposed: four conventional tubeless tires, four puncture sealing tubeless tires, and four dual chamber tires; foldable spare tires; small compressed air container proposed as method of re-inflating.

Possibility of "Spare Tire Elimination" by Use of Dual Compartment Tires, W. LEE. Paper No. 79V. Data presented relating to taxicab service using safety tires indicate that dual compartment principle offers greatest protection against punctures and blowouts and against roadside delays due to tire failures; use of this type of tire would eliminate need of present spare tire.

How May Spare Tire be Eliminated? H. B. HINDIN. Paper No. 79W. Requirements which must be met before spare tire can be eliminated; approach taken by United States Rubber Co. towards elimination of puncture delay; "Air Guard" static tire; reserve chamber tire concept; use of split rim, easily stored fabric tube, and special inflater cylinder.

What User Wants in Governor and What He Has Received, F. HAGUE. Paper No. 80T. Features of governors available for over-the-road vehicle engines; straight vacuum velocity type, centrifugal vacuum type and mechanical governors; recent developments such as road speed, 2-stage, and 2-speed governors; present objectionable features of governor installations; need stressed that provision be made for engine and transmission power take-offs of rugged construction designed for multiple governor application.

Engine Governors can Improve Economy and Durability in Commercial Vehicles, G. R. BEARDSLEY. Paper No. 80U. There are many components in engines and chassis where uncontrolled speeds develop harmful heat loads, high stresses, and functional failures are areas that are adversely affected by excessive engine speed; fuel requirements relative to speeds and total effect of these types of fuel losses upon economical operation of commercial vehicles; governor that is capable of sensing engine load and speed to utilize optimum fuel consumption island would offer greater benefits.

Air Flow Governors — Simple and Economical Approach to Engine Speed Control, R. G. MOREY. Paper No. 80X. Factors to consider in selection of governors for transportation vehicles; reference to King-Seeley Vari-Speed governor; features discussed relative to purpose and function as part of whole; range of Vari-Speed governors available.

Practical Governing for Light Trucks and Passenger Cars, P. N. HANEBUTH. Paper No. 80Z. Design details of Stewart-Warner velocity governor, based upon principle that governor senses only one force and that is impingement of air-fuel flow on unbalanced part of throttle plate; control mechanism.

Radiotracers in Piston Ring Wear, J. THIERY. Paper 66V. Technique, first developed by Atlantic Refining Co., consists in measuring and recording radioactivity of oil continuously circulated around detector apparatus; to overcome certain disadvantages of method, Institut Francais du Petrole developed IFP — RA3 method, principle of which is explained; applicability to Petter diesel and automotive gasoline engines. See also Engineering Index 1958 p. 943.

Mobility for Ground Soldier, H. W. JOHNSON. Paper 67T. Vehicle characteristics that will be needed to provide optimum mobility on battlefield of future, outlined from military viewpoint.

MATERIALS

Steel, R. E. HARVIE. Paper No. 73T. Need for closer cooperation between engineer and metallurgist to produce increasingly better automotive iron and steel components is shown; metals functionalism defined as mechanical properties related to strength and formability.

Compressive Failures in Transmission Gearings, G. E. HUFFAKER. Paper No. 76T. Failures of hardened steel gears in automotive transmissions are usually scoring, bending fatigue, or compressive loading or surface fatigue; paper concerned with compressive loading vs stress repetitions resulting in surface failures of gears in laboratory tests; data from such tests as basis for future gear design examined.

New Elastomers Break Old Barriers, R. P. SCHMUCKAL. Paper No. 82U. Properties and potential of following elastomers: isoprene and butyl rubbers; chlorosulphonated polyethylene; urethane, and nitrile, polyacrylic and silicone rubbers; fluoro-elastomers; comparison of these elastomers with respect to several additional properties of importance in automotive applications; costs of polymers and compounds.

PRODUCTION

Some Cases of Automation in Dauphine Manufacturing Lines, P. E. BEZIER. Paper No. 75T. Charac-

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Briefs of SAE PAPERS

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teristics of car, produced by Régie Nationale des Usines Renault, relating to technical and economical factors; solutions regarding body building, forge, foundry, and machine shop; handling of parts, storage and loading; results obtained.

Changes in Manufacturing Techniques at Chevrolet, R. W. PODLESAK. Paper No. S169. Development of new frame and major processes required to produce it; highlights of departures from conventional processes in 1959 frame operations.

NUCLEAR ENERGY

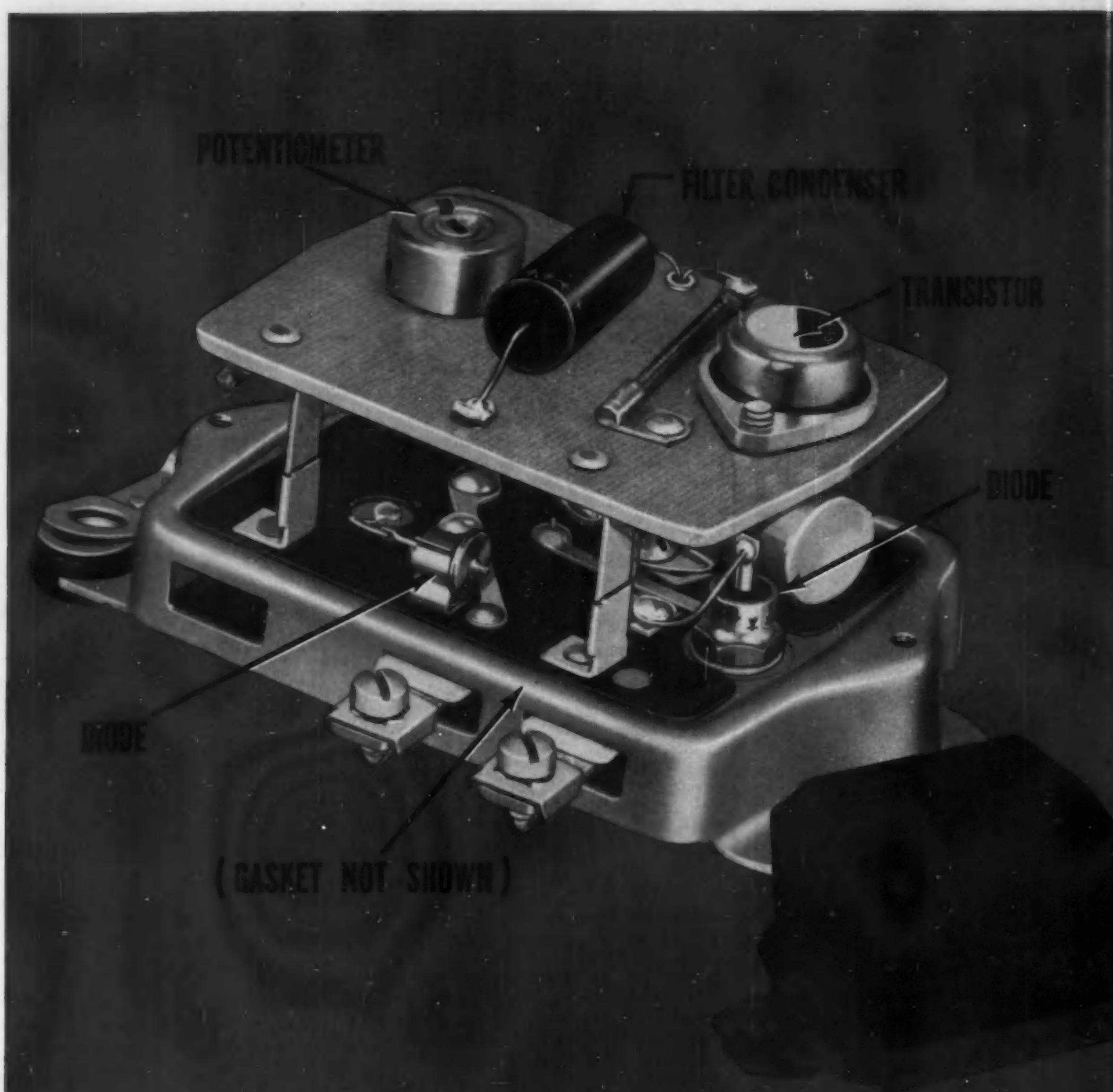
High Energy Accelerators, K. R. SYMON. Paper No. 68T. History and present status of particle accelerator art; existing accelerators and those under construction; special reference to Midwestern Universities Research Assn. (MURA) laboratory engaged in development of new type which promises to extend both beam intensities and collision energies which can be achieved; fixed field alternating gradient (FFAG) synchrotron; advantages of utilizing colliding beams.

MISCELLANEOUS

What is a Marine Engine? H. D. PEACOCK. Paper No. S170. Examination of requirements as follows: performance, durability, dependability, safety of operation, adaptability and economy.

Probable Consequences of Common Market on Motor Car Economy of Western Europe, A. LAURENT. Paper No. 74T. Aim of Common Market created by Treaty of Rome, grouping together six Western European Countries: German Federal Republic (West Germany), Belgium, France, Holland, Italy, and Luxembourg; it represents market of about 168 millions of inhabitants; difficulties due to special circumstances; comparative figures; parallels between United States and Common Market.

· These digests are provided by Engineering Index, which abstracts and classifies material from SAE and 1200 other technical magazines, society transactions, government bulletins, research reports, and the like, throughout the world.



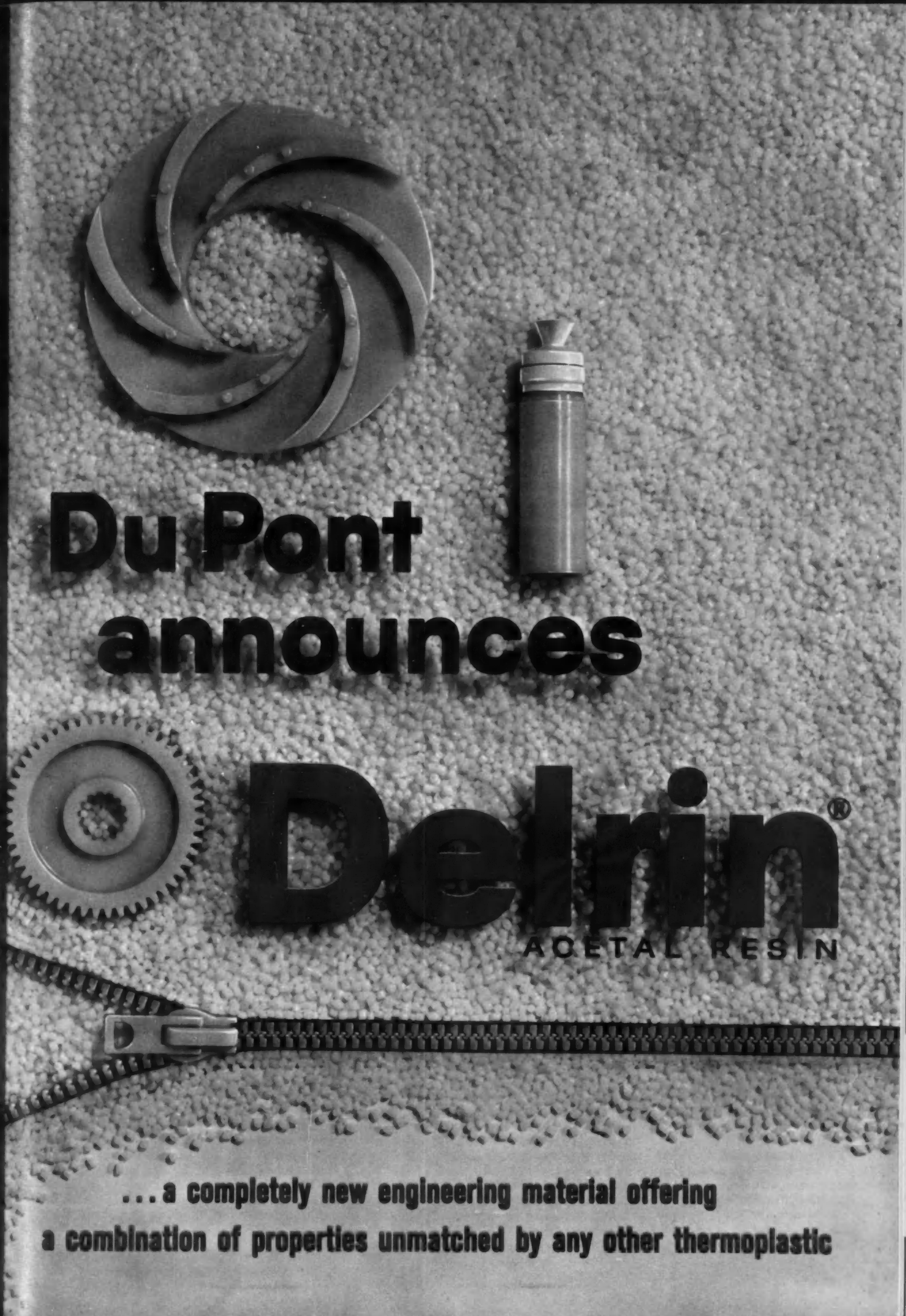
ONLY DELCO-REMY OFFERS FULL-TRANSISTOR

Designed for use with DELCO-REMY'S new self-rectifying a.c. generators

Now you can choose between *two* modern new Delco-Remy regulators—the most accurate available today. One is a full-transistor model, the other transistorized.

The FULL-TRANSISTOR REGULATOR has no moving parts and offers the ultimate in accurate electrical performance, durability and reliability. It is composed entirely of transistors, diodes, condensers and resistors, permitting higher field current for better generator performance. Constant voltage control is unaffected by temperature changes, vibration, or mounting position. A simplified external adjusting feature permits easy voltage setting for varying operating conditions. And this full-transistor regulator requires no periodic servicing.

The TRANSISTORIZED REGULATOR contains a single transistor and diode working in conjunction with a vibrating-type voltage sensing unit. The transistorized circuit


Du Pont
announces
Delrin®
ACETAL RESIN
...a completely new engineering material offering
a combination of properties unmatched by any other thermoplastic

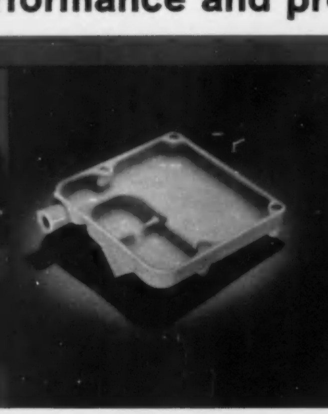
This is Du Pont Delrin:®

"Delrin" acetal resin is a highly crystalline, stable form of polymerized formaldehyde. This completely new material offers you metal-like mechanical properties, such as a high degree of strength and rigidity, plus other properties that metals do not possess.

The combination of properties offered by "Delrin" is unequaled by any other thermoplastic. For example, "Delrin" has high dimensional stability, tensile and flexural strength, resilience and toughness. Most importantly, "Delrin" retains these desirable properties under a wide range of service conditions—temperature, humidity, solvents and stress.

Over the past three years, "Delrin" has been

Typical performance and production advantages of "Delrin"



A brass part in a commercial flush valve was duplicated in "Delrin". This part operated perfectly for 18 months—the period of test—although it was completely and continuously immersed in water. The outstanding dimensional stability of "Delrin" under a wide variety of service conditions has also been proved, for example, in showerheads (continuously running water at 150°F.), and movie projector gears (run over 2,000 hours at ambient humidity).

This textile solution pan is ordinarily made of stainless steel. It must have resistance to oils and organic solvents, a clean, smooth surface; it also requires several threaded inserts plus other details. In normal quantities, stainless steel pans cost approximately $25 each. Injection molded in "Delrin", the cost was quoted at about $3 each. Testing showed that "Delrin" provided the required finish without machining, the needed solvent resistance, plus a weight saving of 75%.

A zinc die-casting mold was used to make this instrument cluster of "Delrin". Weight was reduced over the zinc component by almost 80%. In addition to manufacturing economies, further savings in assembly are indicated: self-tapping screws can be used, since the creep resistance of "Delrin" prevents loosening or stripping. These clusters can be molded in integral color or painted, and with a conventional mold would require little, if any, mechanical finishing.

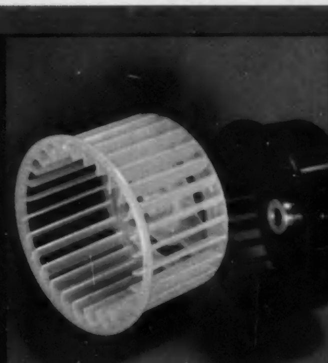
Aerosol containers made of "Delrin" were shelf-stored for over a year; others stored for 3 months at 130°F. In both cases, the contents were still completely dischargeable. "Delrin" retains its strength and toughness for long periods, even when exposed to elevated temperatures and organic solvents. Equally important are the new opportunities for high styling opened by "Delrin"—the freedom to design in new shapes and integral colors to suit purchasing trends.

tested in hundreds of end-use applications by a host of industrial concerns. These tests have confirmed that parts made of "Delrin" can compete *on a performance and cost basis* with parts made of many metals, rubber, glass or wood. Of the various end-uses tested, 75% would normally be made of metal and another 10% of rubber, glass or wood. These tests have resulted in many applications of "Delrin" now being readied for commercial production—including gears, bearings, housings, containers, plumbing and hardware parts, pump impellers, "squirrel-cage" blowers, door handles, clothing fitments and many others.

In addition to metal-like performance, "Delrin" offers you the manufacturing economies inherent in the production methods of the plastics industry. "Delrin" is easily injection molded, extruded, blow-molded or fabricated with conventional machine tools.

Illustrated below are a few of the applications of "Delrin" which have undergone extensive field service tests. The performance and economies listed were indicated during comparative evaluations made with materials in use at the time of the tests. These applications, together with additional data on the following page, may well suggest ways in which this versatile new engineering material can help *you* improve a product, lower its cost or develop new designs for your profit. Your inquiry is invited (see coupon on next page).

evaluated during three years of field tests . . .



Accessories usually made of metal, such as automotive window cranks and refrigerator door handles, can be economically mass-produced in "Delrin" by injection molding. "Delrin" provides required strength and rigidity. Integral colors, a variety of surface effects and functional details can be produced in one operation. Less weight, improved styling, dependable performance and potential cost savings are made possible by "Delrin".

Industrial components such as this "squirrel-cage" blower—as well as a variety of gears, bearings and other mechanical parts—have demonstrated the ability of "Delrin" to compete with various metals on a performance and cost basis. "Delrin" offers excellent fatigue life even when immersed in oil or water. Rapid production of lightweight, intricate components by the injection molding process can lead to substantial manufacturing economies with "Delrin".

Plumbing fixtures made of "Delrin", such as this showerhead, offer the manufacturer new styling and design advantages...and the home owner new latitudes in bathroom décor. Injection molded in integral color, fixtures made of "Delrin" assure builders and home owners of long-term dimensional stability, freedom from rust and mineral build-up. Modern in design, they are durable and dependable in service, and provide opportunities for potential cost savings.

Clothing fitments, such as zippers, clasps and snaps, are also readily and economically molded in "Delrin". Stiffness, toughness and resistance to heat, body oils and perspiration make "Delrin" a logical choice for such uses. Your customers would welcome the light weight, colorability and warm-to-the-touch benefits "Delrin" offers. Extensive field tests have demonstrated that "Delrin" is one of the most promising new materials available to the fitments industry.

TYPICAL PROPERTIES OF "DELRIN" ACETAL RESIN

PROPERTY		ASTM NO.	AVERAGE VALUES FOR "DELRIN"*	
			500X	150X
Elongation	−68°F.	D638	13%	38%
	73°F.	D638	15%	75%
	158°F.	D638	330%	460%
Impact strength, Izod	−40°F.	D256	1.2 ft.lb./in.	1.8 ft.lb./in.
	73°F.	D256	1.4 ft.lb./in.	2.3 ft.lb./in.
Tensile strength and yield point,	−68°F.	D638	14,700 psi	
	73°F.	D638	10,000 psi	
	158°F.	D638	7,500 psi	
Compressive stress at 1% deformation		D695	5,200 psi	
at 10% deformation			18,000 psi	
Flexural modulus,	73°F.	D790	410,000 psi	
	170°F.	D790	190,000 psi	
	250°F.	D790	90,000 psi	
100% RH 73°F.		D790	360,000 psi	
Flexural strength		D790	14,100 psi	
Sheer strength		D732	9,510 psi	
Heat distortion temperature,	264 psi	D648	212°F.	
	66 psi	D648	338°F.	
Fatigue endurance limit, 50 to 100% RH 70°F.			5,000 psi	
100% RH 150°F.			3,000 psi	
Water absorption, 24 hours immersion		D570	0.12%	
equilibrium, 50% RH		D570	0.2%	
equilibrium, immersion, 77°F.			0.9%	
Specific gravity		D792	1.425	
Rockwell hardness		D785	M94, R120	
Flammability		D635	1.1 in./min.	
Melting point (crystalline)			347°F.	
Flow temperature		D569	363°F.	

PROPERTY	ASTM NO.	AVERAGE VALUES FOR "DELRIN"*
Deformation under load (2,000 psi at 122°F.)	D621	0.5%
Coefficient of linear thermal expansion	D696	4.5×10^{-5} per °F.
Taber abrasion (1000 gm. load, CS-17 wheel)	D1044	20 mg/1000 cycles
Thermal conductivity		1.6 BTU/hr./sq. ft./°F./in.
Specific heat		0.35 BTU/lb./°F.
Modulus of rigidity		178,000 psi
Poisson's ratio		0.35
Dielectric constant, 73°F., 10^2-10^5 cps	D150	3.7
Dissipation factor, 73°F., 10^2-10^5 cps	D150	.004
Dielectric strength, short time	D149	500 V/mil
Volume resistivity	D257	6×10^{14} ohm/cm
Resistivity	D257	2×10^{13} ohm
Arc resistance	D495	129 seconds (burns)

		P Factor at 73° F.:	
Permeability:	*Water*	1.9	gms loss/24 hrs/100 in^2 area/mil thickness. Determined on bottles with 35-50 mil wall thickness.
	Ethanol	0.2	
	Freon® 12-114 (20/80)	< 0.2	
	Methyl Salicylate	0.3	

		Room Temp.	122° F.	
Resistance to Organics:	CCl_4	1.2	5.7	% wgt. gain—12 mo. total immersion Vol. change proportional to wgt. change.
	Toluene	2.6	2.8	
	Acetone	4.9	2.6	
	Alcohol	2.2	1.9	
	Ethyl Acetate	2.7	2.9	

*These values are representative of those obtained under standard ASTM conditions and should not be used to design parts which function under different conditions. Since they are average values, they should not be used as minimums for material specifications.

DELRIN® *offers design engineers a new combination of properties*

ACETAL RESIN

"Delrin" acetal resin offers you a combination of properties and potential cost advantages never before offered by any single material. Specific values of typical properties of "Delrin" are listed in the table above . . . and the advantages implicit in these figures have been thoroughly tested in a wide variety of end-uses.

Today is your best opportunity to consider how Du Pont "Delrin" can help you improve the design of a product or develop your designs on new products. Within the next few weeks a new plant to manufacture "Delrin" in commercial quantities will come on stream at Parkersburg, W. Va. This plant is your assurance that your design improvements can fast become practical realities. Commercial molders, already familiar with "Delrin", can provide you with valuable assistance in your problem.

A specialized group of Du Pont engineers, as well, can help you with their experience and knowledge gained during years of market development work with "Delrin". They may well have tested the very product or component you are considering.

FOR MORE SPECIFIC INFORMATION MAIL THIS COUPON

E. I. du Pont de Nemours & Co. (Inc.), Advertising Department
Nemours Building, Rm. 99D, Wilmington 98, Delaware

I am interested in evaluating "Delrin" for the following use:________

NAME ________

COMPANY ________ POSITION ________

STREET ________

CITY ________ STATE ________

In Canada: Du Pont of Canada Limited, P.O. Box 660, Montreal, Quebec.

DELRIN®

ACETAL RESIN

DU PONT

REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

KNOW YOUR ALLOY STEELS . . .

III

This is the third of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

What Does Grain Size Mean In An Alloy Steel?

The grain size of alloy steels is generally understood to mean austenite or inherent grain size, as indicated by the McQuaid-Ehn carburizing test. Austenite grain size should be distinguished from ferrite grain size, which is the size of the grains in the as-rolled or as-forged condition with the exception of those steels that are austenitic at room temperature. When steel is heated through the critical range (approximately 1350 to 1600 deg F for most steels, depending on the composition), transformation to austenite takes place. The austenite grains are extremely small when first formed, but grow in size as the temperature above the critical range is increased, and, to a limited extent, as the time is increased. It is apparent, therefore, that both time and temperature must be constant in order to obtain reproducible results.

When temperatures are raised materially above the critical range, different steels show wide variations in grain size, depending on the chemical composition and the deoxidation practice used in making the heat. Heats are customarily deoxidized with aluminum, ferrosilicon, or a combination of deoxidizing elements. Steels using aluminum or other deoxidizers in carefully controlled amounts maintain a slow rate of grain growth at 1700 deg F, while heats finished with other deoxidizers, usually ferrosilicon, develop relatively large austenite grain size at temperatures somewhat below 1700 deg F.

The McQuaid-Ehn test is the one ordinarily used for determining grain size. Steel is rated with a set of eight ASTM charts that are compared one at a time with a specially prepared steel sample until one is found to match. Number 1 grain size, the coarsest, shows 1½ grains per sq in. of steel area examined at 100 diameters magnification. The finest chart is Number 8, which shows 96 or more grains per sq in. at the same magnification.

Properties Affected by Grain Size

Fine-grain steels (grain sizes 5, 6, 7, and 8) do not harden as deeply as coarse-grain steels, and they have less tendency to crack during heat-treatment. Fine-grain steels exhibit greater toughness and shock-resistance—properties that make them suitable for applications involving moving loads and high impact. Practically all alloy steels are produced with fine-grain structures.

Coarse-grain steels exhibit definite machining superiority. For this reason a few parts which are intricately machined are made to coarse-grain practice.

The correct specification and determination of grain structure in steel is a subject that has been given long study by Bethlehem metallurgists. If you would like suggestions on this or any other problem concerning alloy steels, these men will be glad to give you all possible help.

In addition to the entire range of AISI alloy steels, Bethlehem produces special-analysis steels and the full range of carbon grades.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

One in a series of technical reports by Bower

BEARING BRIEFINGS

ROLLER GUIDANCE–VITAL FACTOR IN BEARING LIFE

Roller guidance has been established by the Anti-Friction Bearing Manufacturers Association as a major rating factor for roller bearings. There is a direct relationship between this factor and the life and capacity of a cylindrical roller bearing under load.

Figure 1 illustrates the results of a loose fit between a roller and the guiding ribs of the raceway. Because of lack of guidance by the ribs, the roller is free to skew and skid under load. Such a condition invariably leads to early bearing failure.

To achieve close roller fit and proper roller guidance, Bower precision grinds each bearing race on specially designed centerless grinders. In this operation, Bower positions the integral raceway ribs *from the theoretical centerline of the bearing*. This method produces bearings with high dimensional accuracy and perfect symmetry.

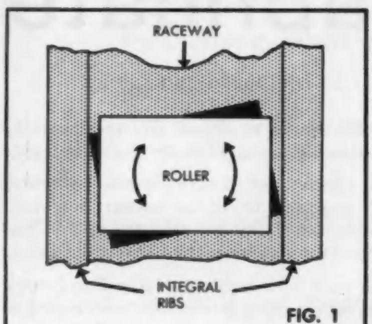


FIG. 1

Fig. 1. Loose fit in raceway means poor roller guidance. Roller can skew and skid under load.

In addition, the close tolerances held in grinding the roller track and integral guiding ribs give Bower cylindrical roller bearings the ability to *take thrust in any direction*. A Bower cylindrical roller bearing has thrust capacity of from 10-15% of its rated radial capacity!

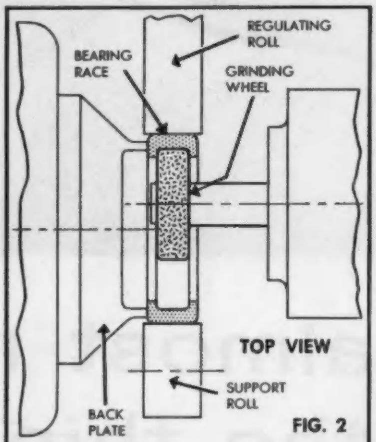


FIG. 2

Figures 2 and 3 diagram the centerless grinding method used to finish Bower raceways. Use of this technique assures not only optimum roller guidance and maximum bearing life, but also virtually eliminates bearing runout. BEARING SYMMETRY WHICH RESULTS FROM THIS TECHNIQUE PERMITS ACCURATE SHAFT LOCATION REGARDLESS OF HOW THE OUTER RACE AND ROLLER ASSEMBLY ARE INSTALLED. IT COMPLETELY ELIMINATES THE POSSIBILITY OF IMPROPER INSTALLATION.

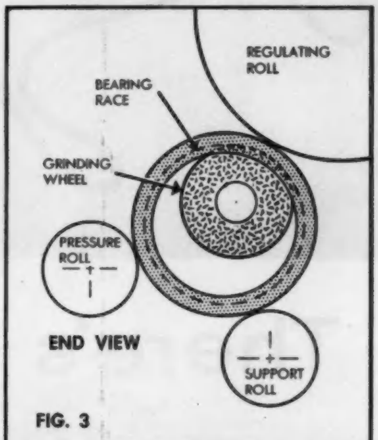


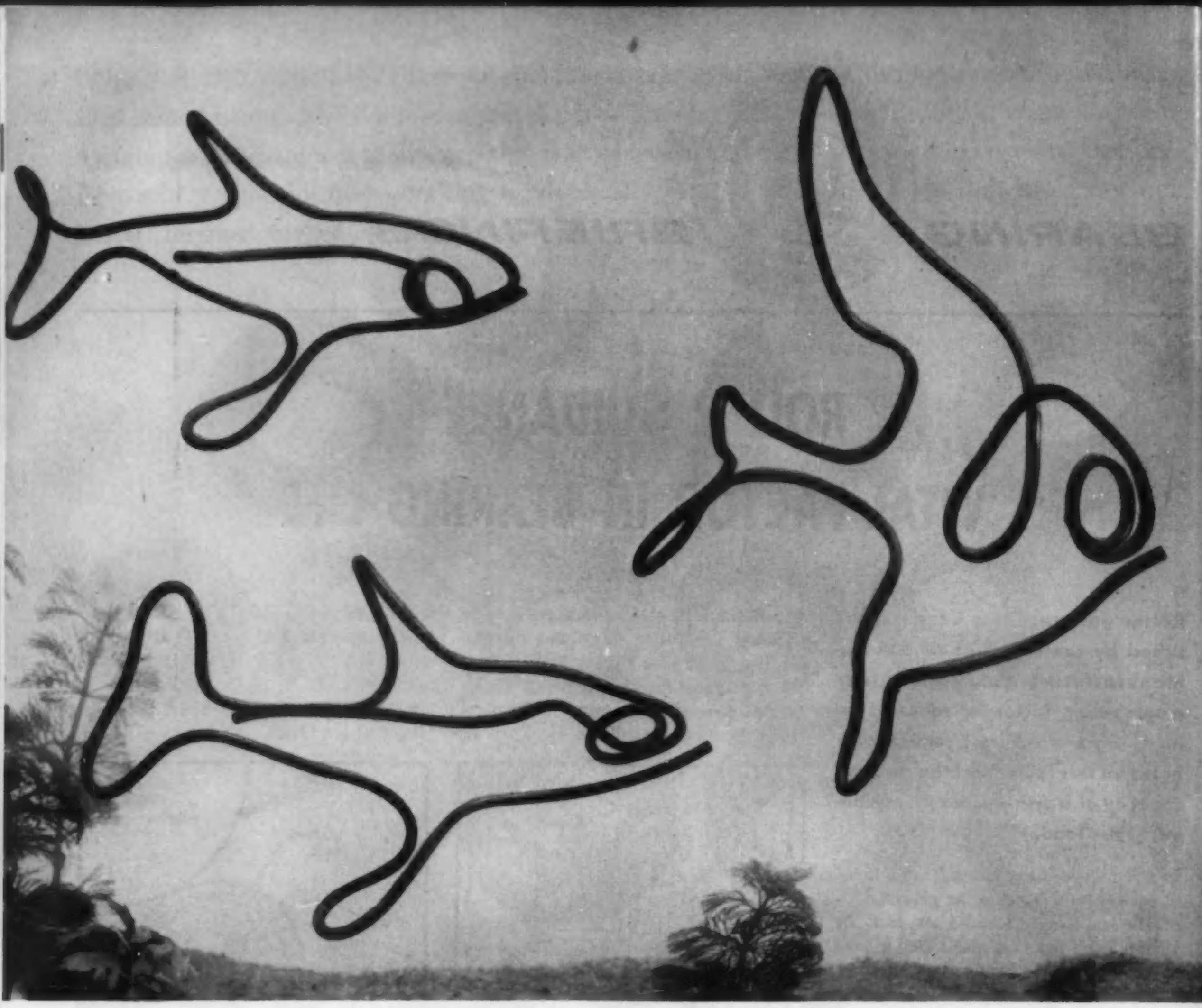
FIG. 3

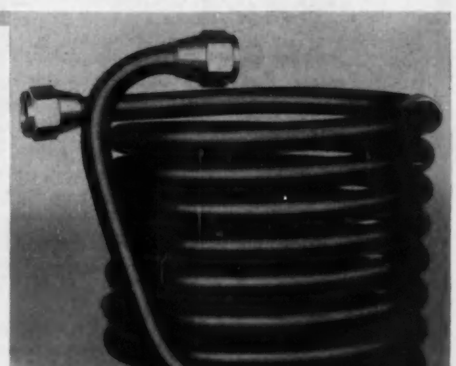
★ ★ ★ ★

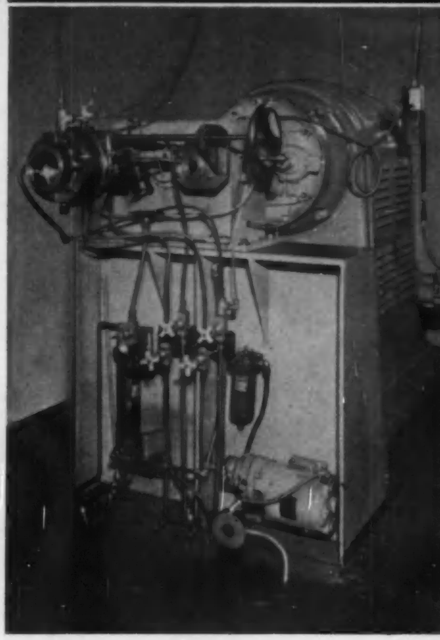
Whatever your bearing needs, we suggest you consider the advantages of Bower bearings. Where product design calls for tapered or cylindrical roller bearings or journal roller assemblies, Bower can provide them in a full range of types and sizes. Bower engineers are always available, should you desire assistance or advice on bearing applications.

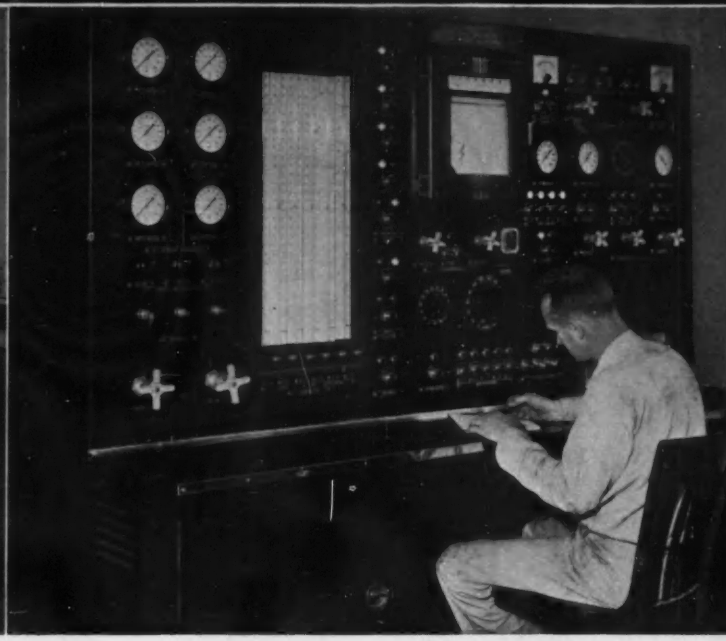
BOWER ROLLER BEARINGS

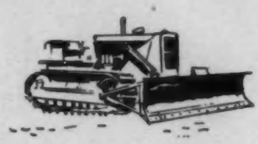
BOWER ROLLER BEARING DIVISION — FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN











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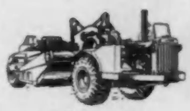

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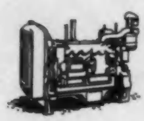

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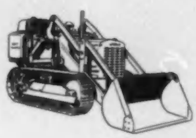

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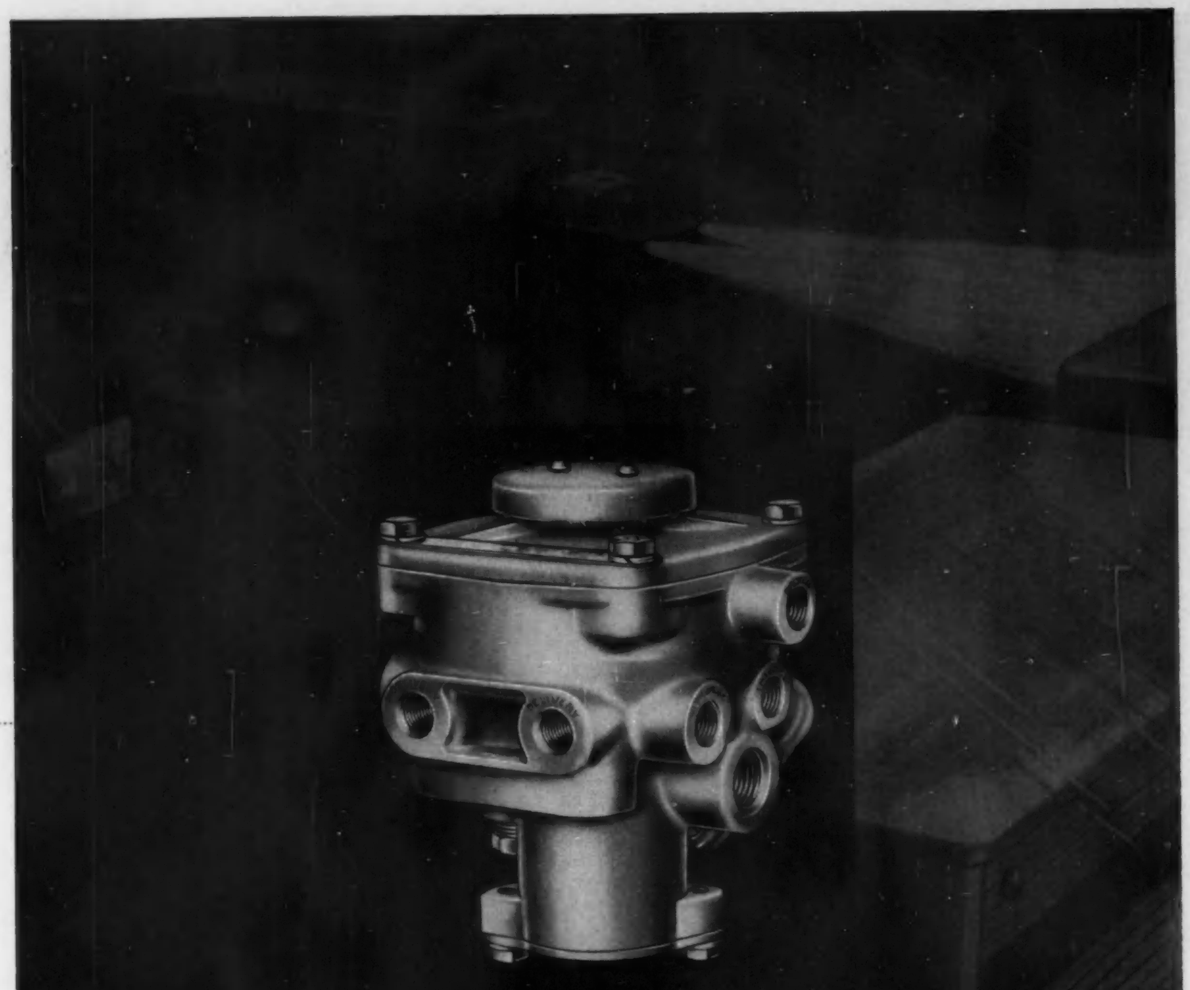

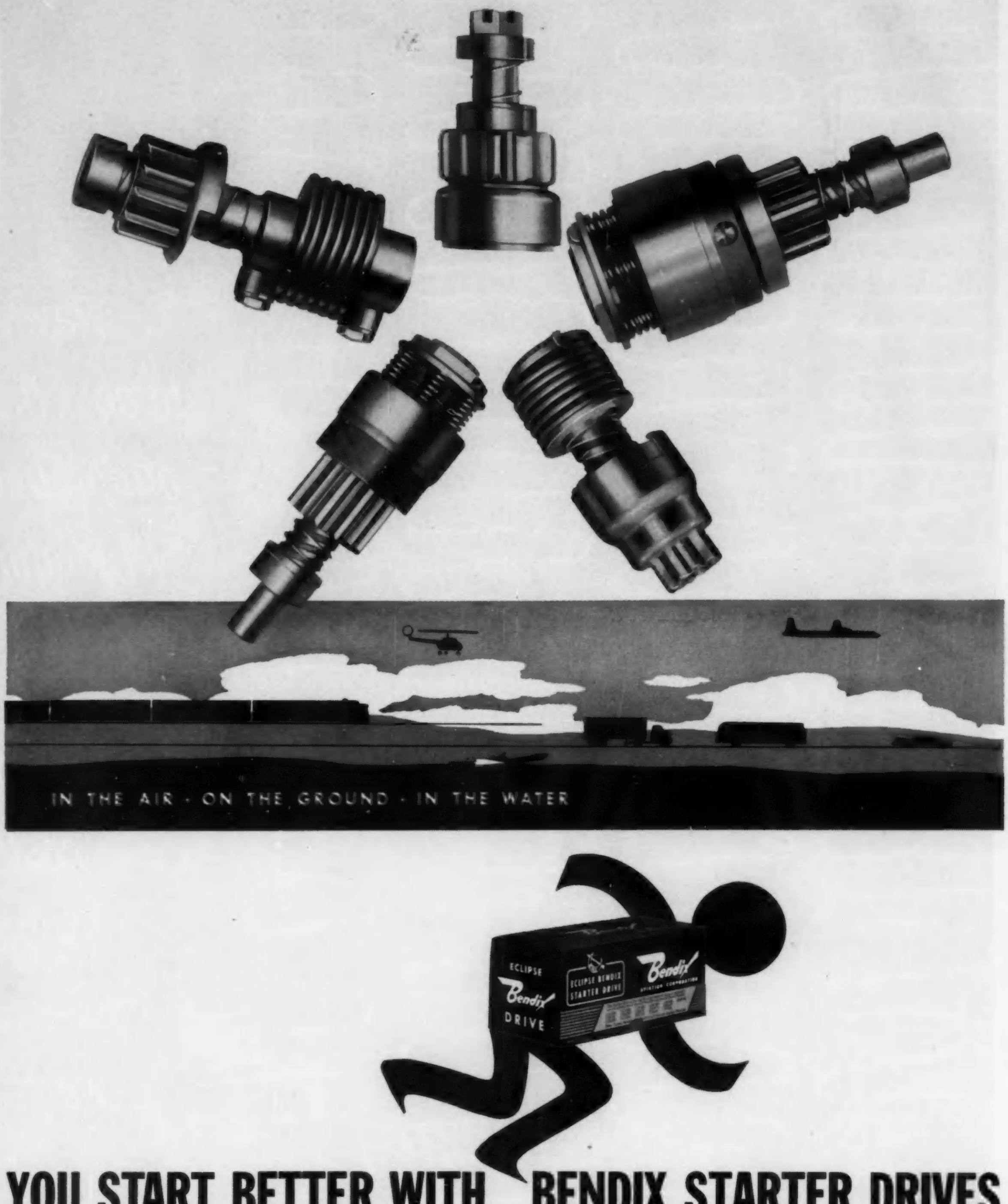
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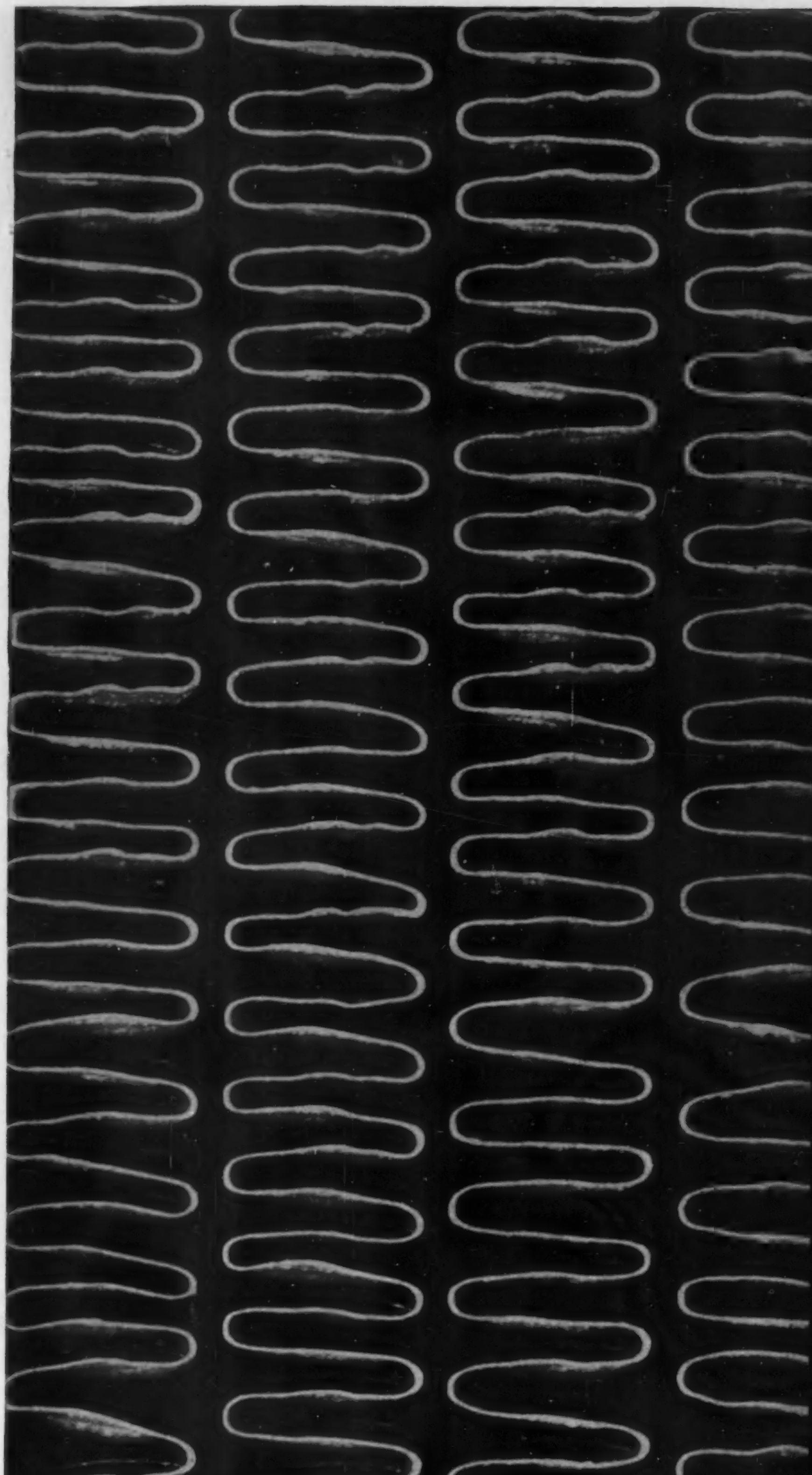
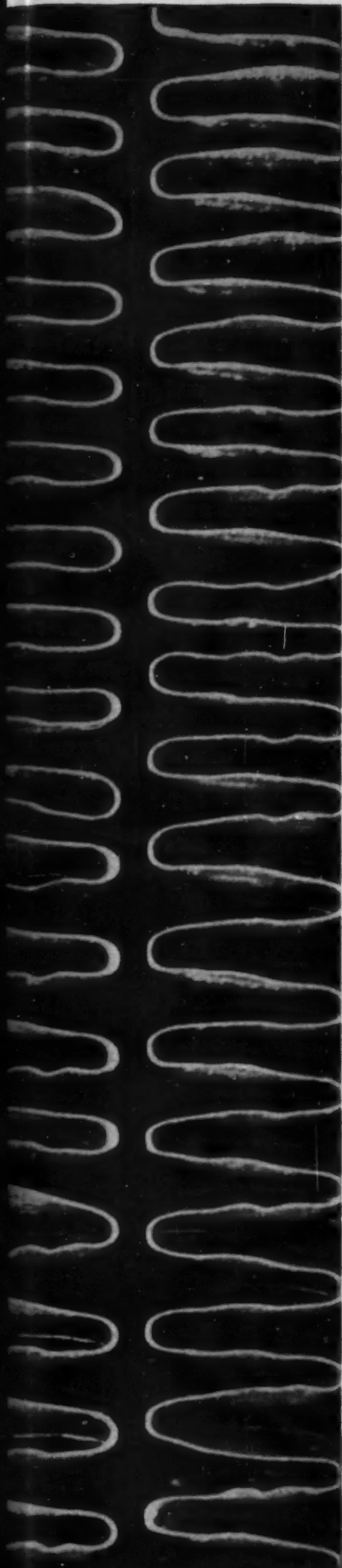


Ready to go...the aluminum radiator

Cuts material costs ...trims front-end weight



New Hydraulic Filter

Removes particles of all sizes to practically zero Microns

...tests with Aircraft & Missile hydraulic oils

show MICROCELL **99.99%** *effective*

At last here is a hydraulic filter that has been *proven in the field* to remove all particles down to practically zero microns!

Luber-finer, Inc., with 25 years experience in oil refining and filtration design and development, combined its "know-how" with years of testing to produce the Microcell filter for the aircraft and missile industry. For the past three years the performance of the Microcell filter has been proven in the field on hydraulic test stand applications and on mobile and portable service units.

Now Luber-finer, Inc. is satisfied with its performance record. Independent laboratory tests show the Microcell removes about 95% of everything down to 2 microns in one pass. After additional passes or circulations through the filter, 99.99% of everything down to practically zero microns can be removed. Microcell filter is now ready for wider distribution to companies in need of such extremely fine micronic filtration, offered for the first time by the Microcell.

Tests have also proven that the Microcell filter will not adversely affect the characteristics or performance of the oil. It actually improves operational performance through more thorough dispersion of the additives.

Another advantage of the Microcell filter is its ability to carry a heavy captured dirt load and still perform efficiently without plugging up. One Microcell Pack can remove and hold up to 150 grams of contaminants from hydraulic oils and still perform efficiently.

Mail the coupon today for more free information about the revolutionary Microcell—including graphs of performance characteristics, 200× magnification photos of various stages of filtered oil, installation drawings, etc.

Luber-finer
INCORPORATED

Here are some of the users of the Microcell filter on test stands and mobile service units.

Rocketdyne Division
North American Aviation, Inc.
Canoga Park, Calif.

Raytheon Company
White Sands, New Mexico

Aerojet General Corp.
Azusa, Calif.

Republic Aviation Corp.
Long Island, New York

Vickers Incorporated
Torrance, Calif.

The Hufford Corporation
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Please send complete information on your new Hydraulic Filter which has been proven 99.99% effective in removing all particles down to practically zero microns.

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ADDRESS

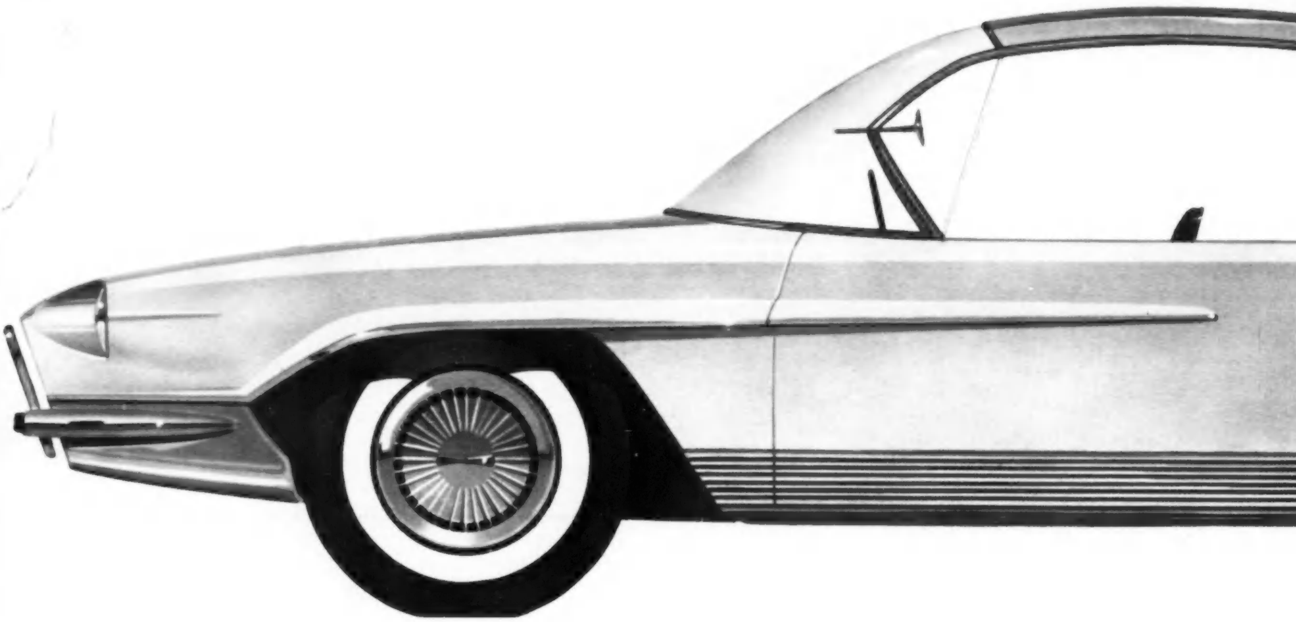
CITY AND ZONE

STATE

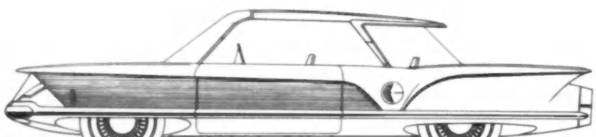
Will you be building this car?

...using the highest-quality aluminum

now being produced in America?



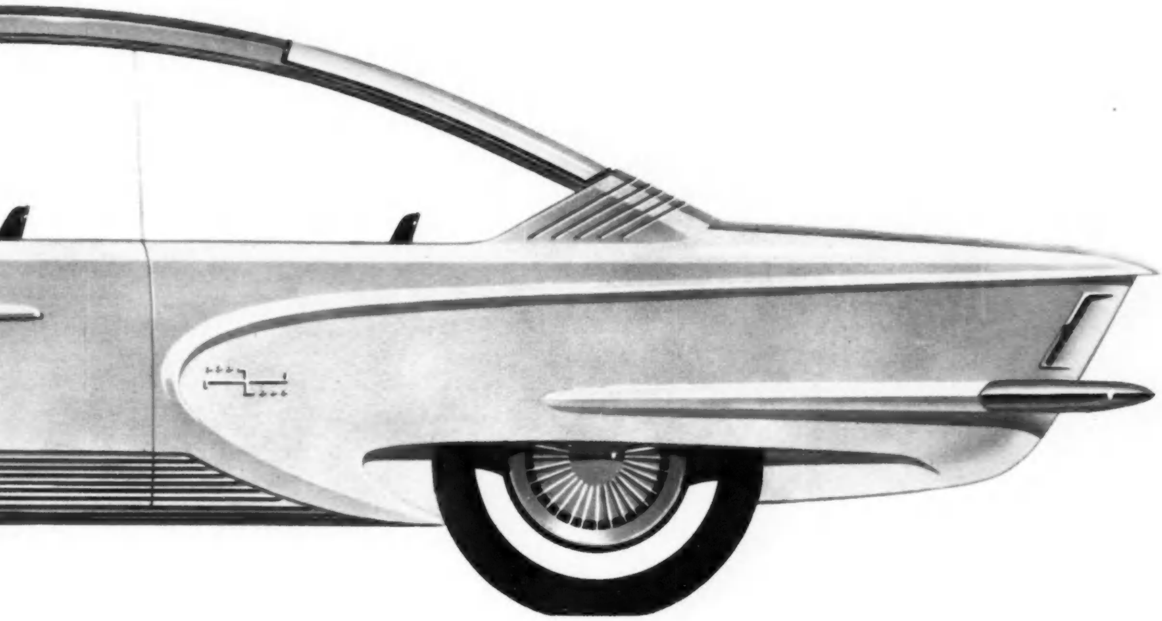
The Menehune *(Men*



The Menehune is a Kaiser Aluminum approach to
small-car concept . . . featuring the low initial cost
economies of lightweight aluminum. Pan-type fra
engine, body and bumpers—*all aluminum!*

And you may be certain that you will be building
Menehune, or components suggested in its design. Ev
and more aluminum is being designed into America

"What Is The Difference In Aluminum From F



 (and please turn to back page)

LIPE Clutches Cut Truck Operating Costs

say increasing numbers of big users . . .

It's what the clutch does on the road that sells the experienced truck user. His only measuring stick is overall costs. In important and increasing numbers, that measure is causing him to buy Lipe Heavy-Duty DPB's . . . both on new trucks and as replacements of original equipment.

Don't risk the owner loyalty of this big and growing body of users. Sell them what they want . . . LIPE . . . either as standard or optional equipment. Let the men who pay the bills prove to you that . . .

the trend is to LIPE.

For more ton-miles and more engagements between shop-stops, equip with Lipe Heavy-Duty DPB Clutches. Single and two-plate types; 12", 13", 14" and 15" sizes: torque capacities from 300 to 1900 ft.-lbs.

LIPE ROLLWAY

Lipe-ROLLWAY CORPORATION
SYRACUSE 1, N. Y.

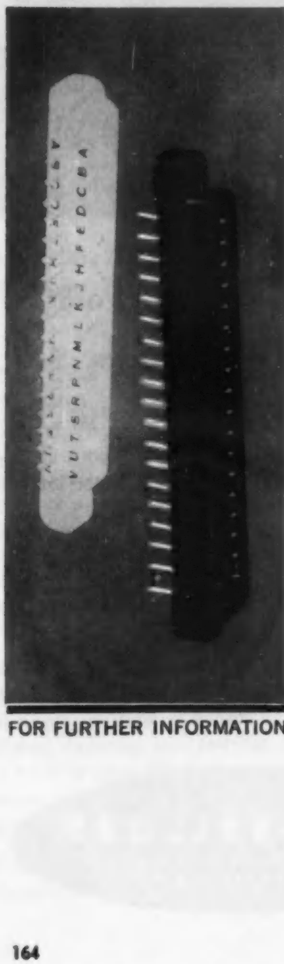
Plaskon Nylon News

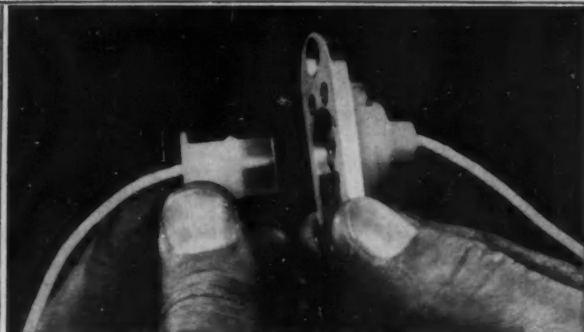
Type 6 • Nylon's Range of Applications Expands!

MORE AND MORE INDUSTRIAL AND CONSUMER PRODUCTS MAKE USE OF ITS OUTSTANDING PROPERTIES

Durable Electrical Circuits

Space Products, Long Beach, Calif., uses flexible Plaskon Nylon 8200 for circuit connectors because it produces higher uniformity of finished parts yet lowers manufacturing costs. These "Ezi-Connectors" feature beryllium contacts, with a fatigue resistance twice as great as that of spring brass or phosphor bronze. They are moisture-proof and can be easily and repeatedly inserted and removed. Available in several colors, they are lettered to permit easy assembly and identification.





Reliable Missile Fire Connector

Plaskon Nylon 8200's outstanding durability, light weight and resilience are put to good use in this missile fire connector. Injection molded nylon provides excellent insulation and seal against contaminants and moisture for the connector's contacts, as well as mechanical protection for the unit itself. The manufacturer, Alden Products, Brockton, Mass., reports that Plaskon Nylon 8200 enables him to achieve the highest compactness and reliability for this vitally important missile component.

High Strength Closures

This smooth, lustrous Plaskon Nylon cap nut will not scratch, snap or tear other surfaces as do metal caps. Ideal for use in the furniture and electronics industries, the "Relok" Nut is rust-proof, anti-magnetic and self-locking. Plaskon Nylon's high strength and impact resistance enable it to withstand rugged duty. The Lehigh Metal Products Company, Cambridge, Mass., supplies the "Relok" Nut in several lengths and colors.

Superior Ballcock Valve

The Hydo Valve Corporation, Austin, Texas, manufactures this ballcock toilet valve with injection molded Plaskon Nylon 8200. The valve's superior action cuts water closet fill time in half and eliminates noise and seepage. Plaskon Nylon is ideal for products of this type because of its high resistance to heat, chemicals and abrasion. Also, nylon's light weight produces a more compact unit, which can be more economically stored and shipped.

Extra Extrusion Economy! Plaskon Nylon Extrusion Compound 8205 maintains high-melt viscosity through successive regrinds. Scrap can be re-extruded several times without the slightest deterioration of basic properties.

FOR FURTHER INFORMATION OR TECHNICAL ASSISTANCE, WRITE TO OUR NYLON PRODUCT DEVELOPMENT DEPARTMENT.

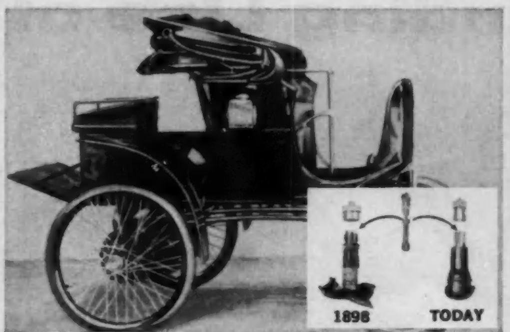
PLASTICS AND COAL CHEMICALS DIVISION

40 Rector Street, New York 6, N.Y.

Allied Chemical

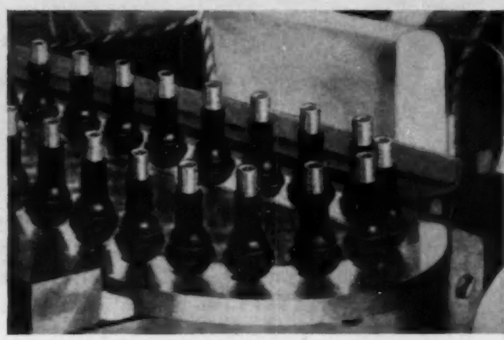
greatest enterprise—depends on tire accomplishments

valves that match the outstanding performance of all tires!

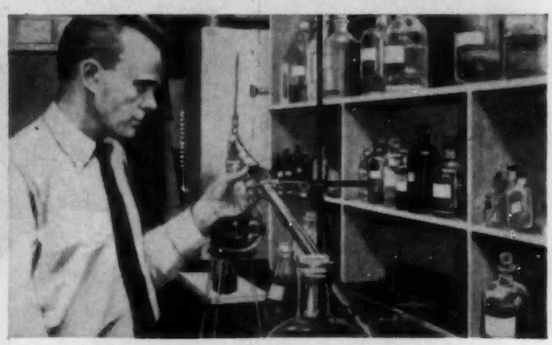


EXTRA DECADES OF EXPERIENCE. Schrader produced the first standard tire valve in 1898. Today's valve core fits the valve housing of 1898 with equal facility.

INDUSTRY WIDE COOPERATION. America's Automotive, Tire and Tire Valve Industries discovered many decades ago that cooperative efforts were mutually beneficial.



COMPLETE MODERN FACILITIES. Schrader is equipped to design and produce valves for the most advanced tires for any vehicle, with guaranteed performance.



RIGID QUALITY CONTROL. This important Schrader program is so successful that tire valve performance is taken for granted on vehicles the world over.

The greatest achievement of the automotive industry is mass production of high quality at low cost. This single factor, accomplished in only sixty years, has made our country's standard of living the highest in the world. How? By the cooperation of many companies in the Automotive, Tire and Tire Valve Industries . . . the pooling of experience, ideas, and information . . . the wise investment of brains, time, and money in ever better facilities . . . the specialization of skills. Schrader, for example, designs and produces such practical, dependable valves that tire and vehicle designers never need restrict themselves with valving problems. Schrader Tire Valves match best performance of best tires . . . and always have on every vehicle that rolls.

Schrader®
a division of SCOVILL

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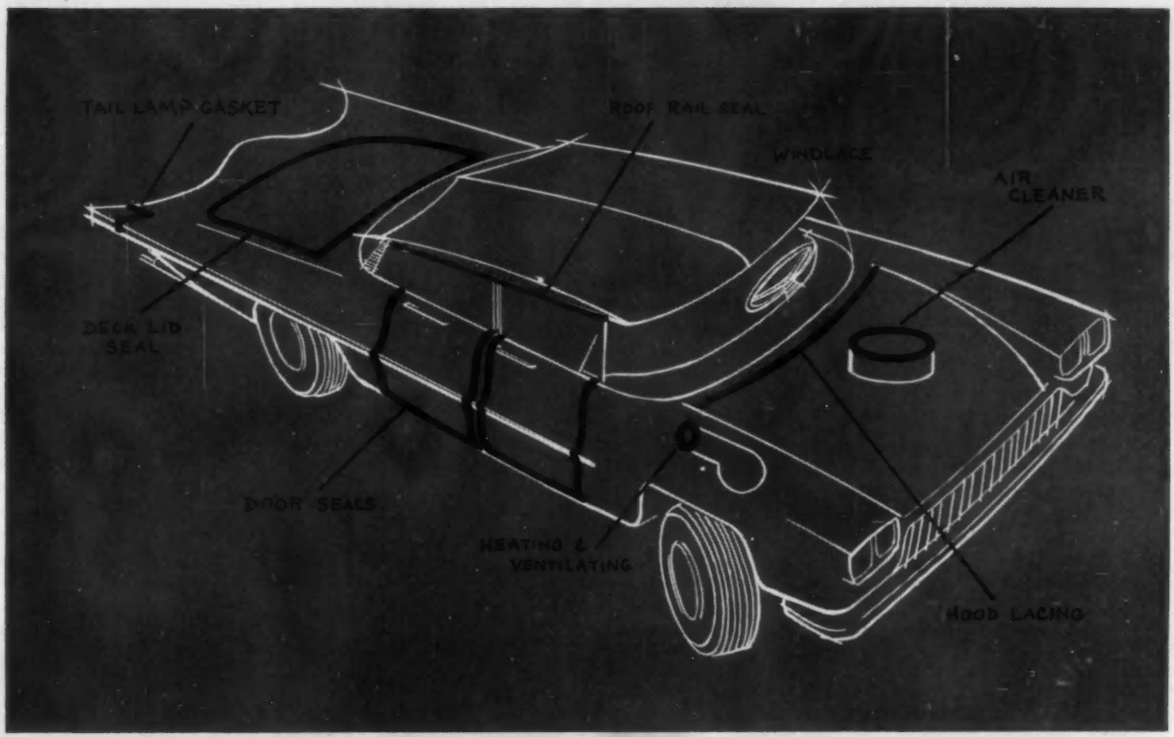
Division of Scovill Manufacturing Company, Inc.

FIRST NAME IN TIRE VALVES

FOR ORIGINAL EQUIPMENT AND REPLACEMENT

A new and improved body seal: extruded closed cell neoprene

New approaches to body sealing and gasketing are possible with extruded closed cell neoprene. It can be extruded into low-pressure body seals of controlled softness that are weather and ozone resistant, and have low water absorption. The "self-skin" of these extrusions and the closed cell structure beneath removes the need for a protective coating. Tighter radii can be turned without wrinkling, providing an effective seal. For more information write for your copy of EXTRUDED CLOSED CELL NEOPRENE SPONGE. E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. SAE-10, Wilmington 98, Delaware.



Applications of extruded closed cell neoprene.

Complex cross sections can be extruded.

DU PONT

Better Things for Better Living . . . *through Chemistry*

SYNTHETIC RUBBER

NEOPRENE
HYPALON®
VITON®
ADIPRENE®

DOW | **New keys to automotive progress**

The keys are Dow plastics and they're opening up a bright new world of opportunities in the design, engineering and production of today's finest automobiles. From automotive chemistry at Dow comes a steady stream of these versatile materials that not only expedite production, but make significant contributions to motoring comfort and pleasure. It will pay you to make note of Dow automotive products highlighted on these pages.

You may wish to check certain items in this advertisement and forward to those concerned in your company.

ROUTE TO:

PLASTICS SPEED PARTS PRODUCTION . . . CUT COSTS

Two famous Dow plastics cut costs and improve the quality of highly complicated molded parts for two of motordom's fine car manufacturers.

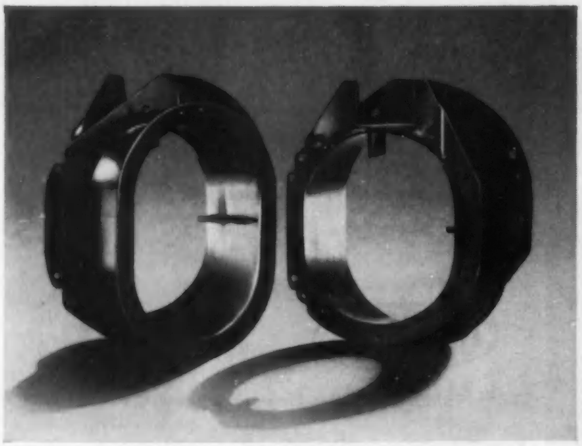
For many years, plastics have been contributing more and more to the interior and exterior appearance and serviceability of automobiles. Their easy moldability, their durability and limitless color range have given automotive engineers a new freedom of design, unavailable in conventional materials. From acid resistant battery caps to the smartest upholstery fabrics, plastics have proved the most versatile materials in the automotive world.

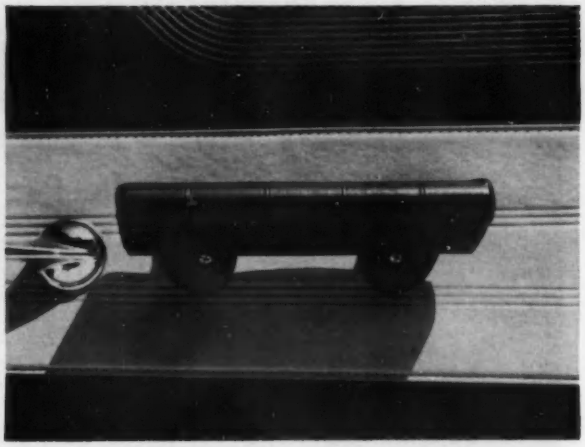
One news-making application for plastics is the fresh air valve body made of Styron®440 for one of America's finest '59 models. This injection-molded unit is lighter in weight and can be produced more efficiently than previously used materials.

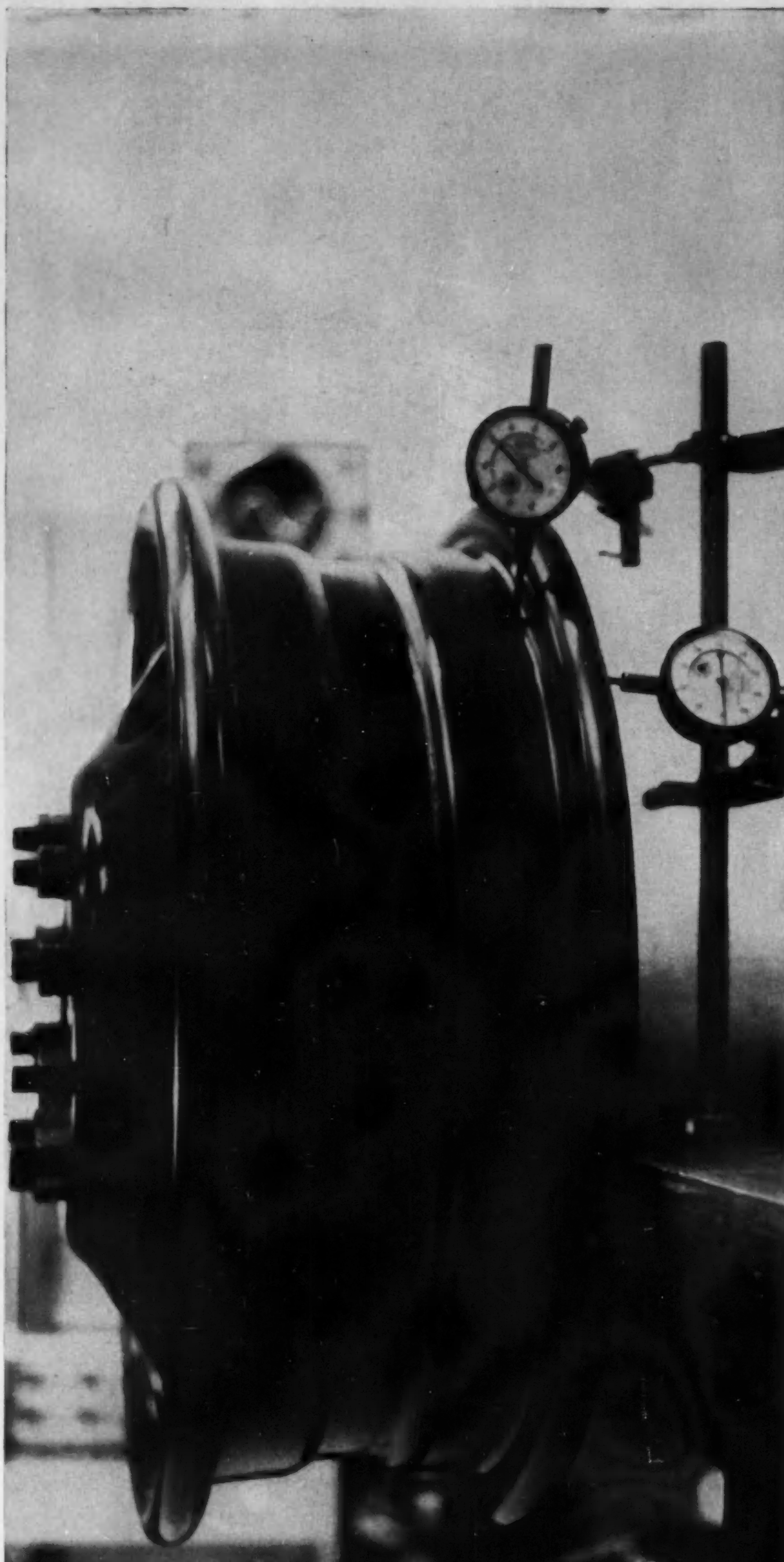
Styron is well known for its fidelity to detail in the most complicated moldings. And Styron 440 provides the most effective heat resistance over a wide temperature range.

Ethocel®, another prominent member of the Dow family of thermoplastics, has made possible new styling and serviceability in the arm rest base of another leading automobile. Here, the manufacturer has made the most of the moldability . . . the outstanding strength and impact resistance . . . the wide color range . . . of the aristocrat of thermoplastic materials. And it can be vacuum metalized to add to its styling potential. Ethocel has provided a better part without increasing its cost.

The Dow family of thermoplastics offers the widest range of formulations in the industry . . . plus technical assistance in the application of these materials to automotive needs.

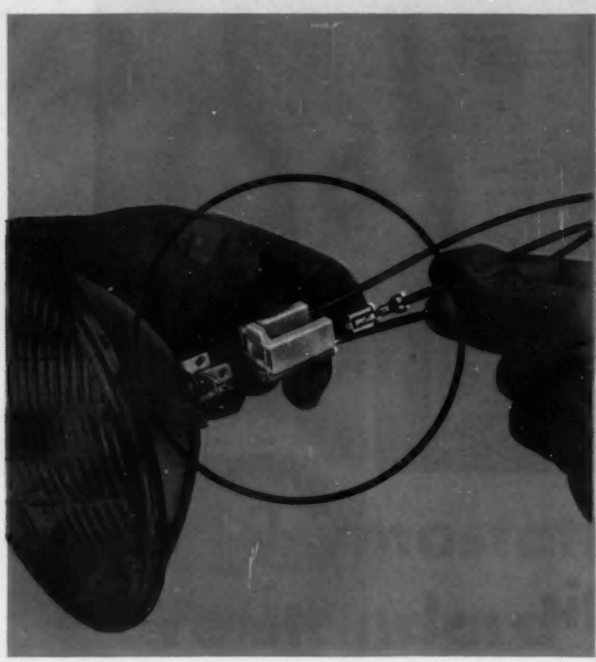


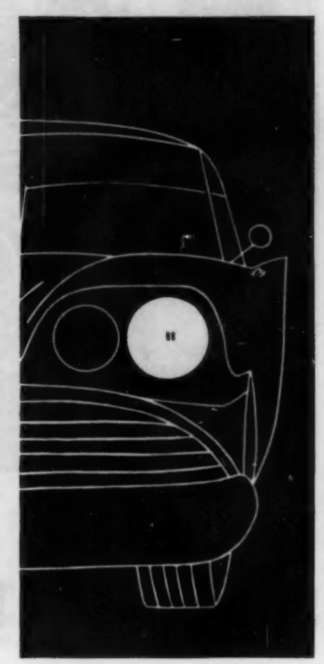





MIDLAND

IT'S A SNAP . . .





THE A-MP FASTIN-FASTON SAVES TIME AND MONEY ON YOUR SEALED BEAM HEAD LAMP CONNECTIONS

The new A-MP FASTIN-FASTON snaps onto sealed beam head lamps with a thrust of the fingers. For two or three tabs. The FASTIN-FASTON obsoletes all other connectors, ends inspection rejects, saves on installation time and costs while assuring uniform quality.

FASTIN-FASTON housing made of Cycolac for excellent dielectric characteristics.

Tab receptacles self-lock in housing . . . offer highest electrical values and rugged, vibration resistance. Compression crimp for maximum conductivity.

No auxiliary parts or accessories.

Unvarying performance and lower cost . . . a snap for the all new A-MP FASTIN-FASTON.

For more information, write today.

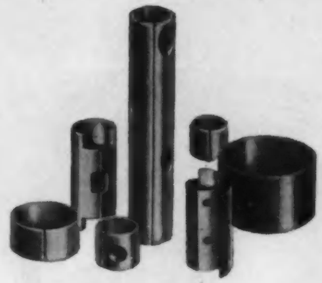
AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

A-MP products and engineering assistance are available through subsidiaries in: Canada • England • France • Holland • Japan

ROLLED SPLIT SPACER TUBES

Save money, time, materials! Substitute these economical spacer tubes for costly parts machined from pipe or tube. Made of steel, aluminum or stainless to your exact dimensions. Furnished plain or plated.



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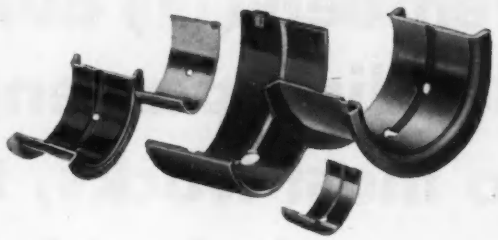
Solid bronze, or steel with bronze on one or both faces. Cold-rolled for extra hardness. Flat, spherical or special shapes. Grooves, holes, nibs, lugs, scallops.

SLEEVE BEARINGS

Tin- or lead-base babbitt, copper alloys, aluminum alloy. These alloys, applied to steel backs, meet 95% of today's engine bearing requirements.



PLAIN and BIMETAL BUSHINGS

Plain: Solid bronze, steel or aluminum. *Bimetal:* Steel lined with bronze, babbitt, copper or aluminum alloy. With oil holes, grooves, slots, notches as required in your application. Straight, lock or special seams.

Consult our Engineering Department for design information, or send for literature.

FEDERAL Mogul SINCE 1899

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FEDERAL-MOGUL-BOWER BEARINGS, INC., 11035 SHOEMAKER, DETROIT 13, MICHIGAN

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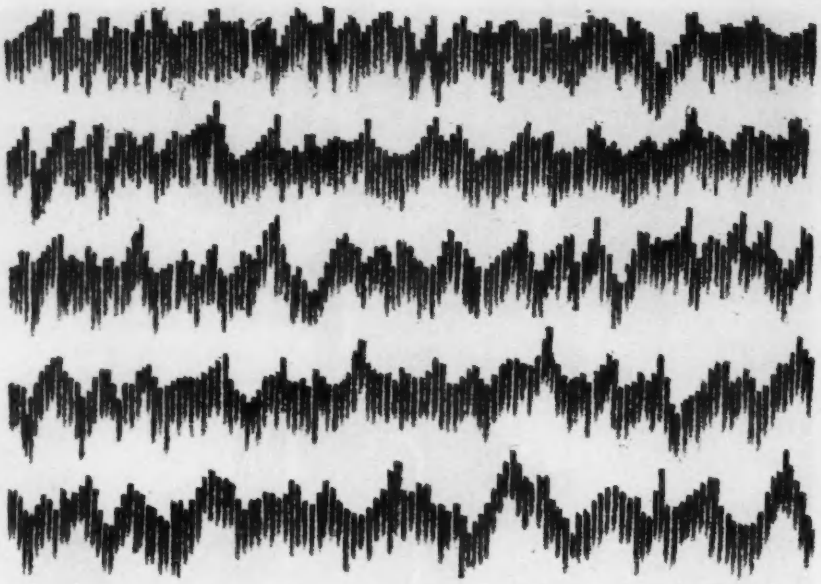
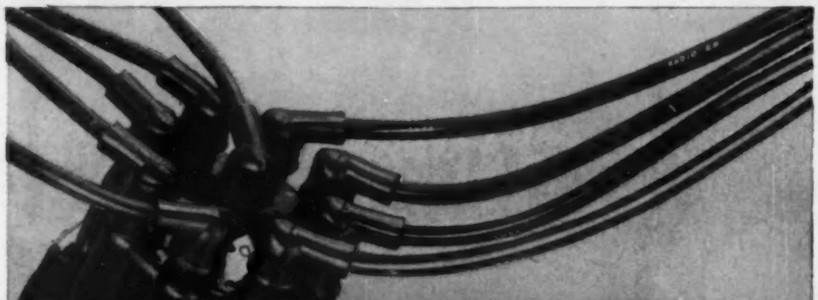
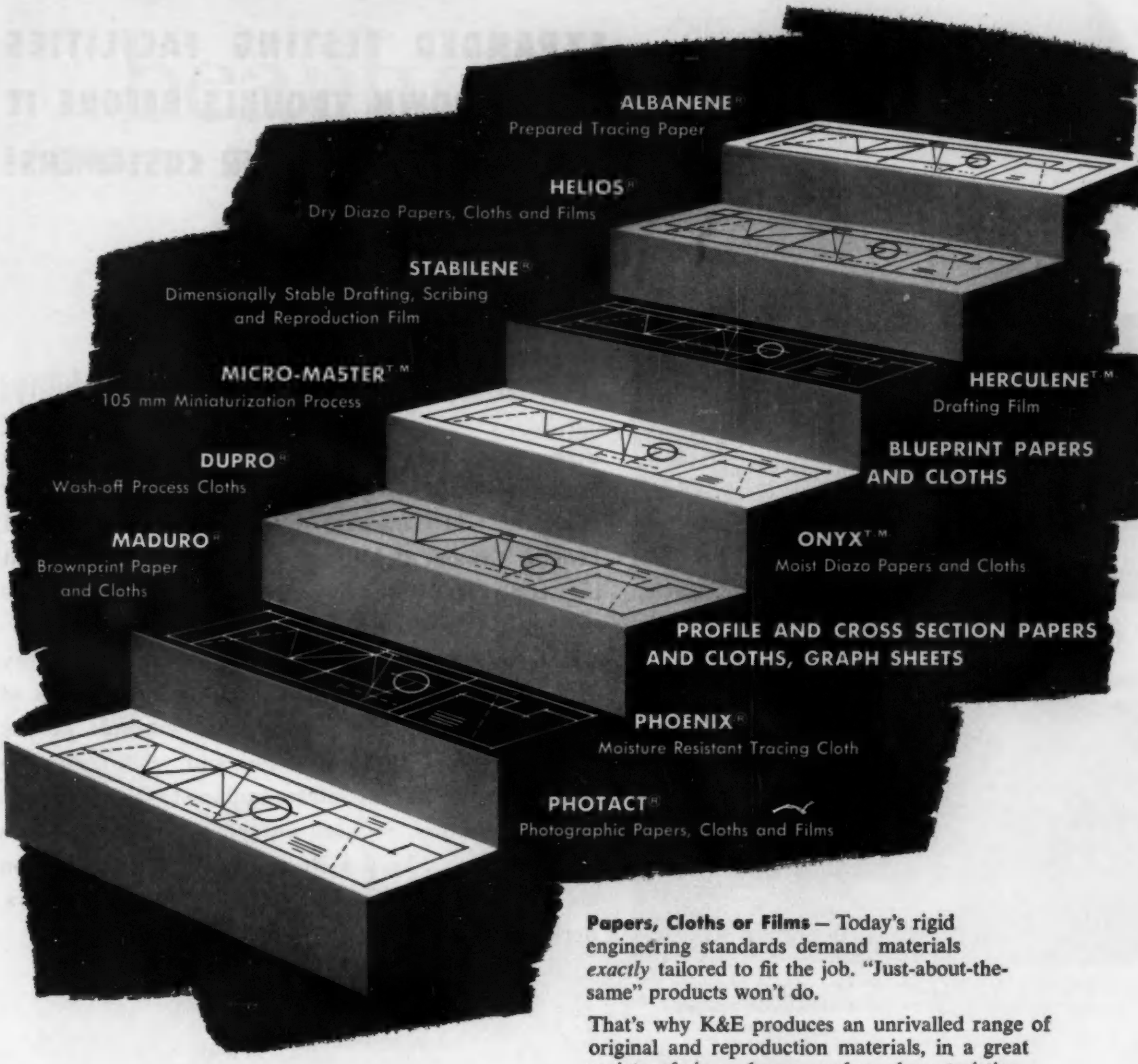
HOT AND COLD ROLLED SHEET AND STRIP STEELS

Detroit 17, Michigan





Use the right material every step of the way



Papers, Cloths or Films – Today's rigid engineering standards demand materials *exactly* tailored to fit the job. "Just-about-the-same" products won't do.

That's why K&E produces an unrivalled range of original and reproduction materials, in a great variety of sizes, shapes, surface characteristics and working properties to choose from.

Whatever your need, K&E can give you the *right* material to do the job. Write for details and samples (please specify the particular products which interest you) to Keuffel & Esser Co., Hoboken, New Jersey. 1620

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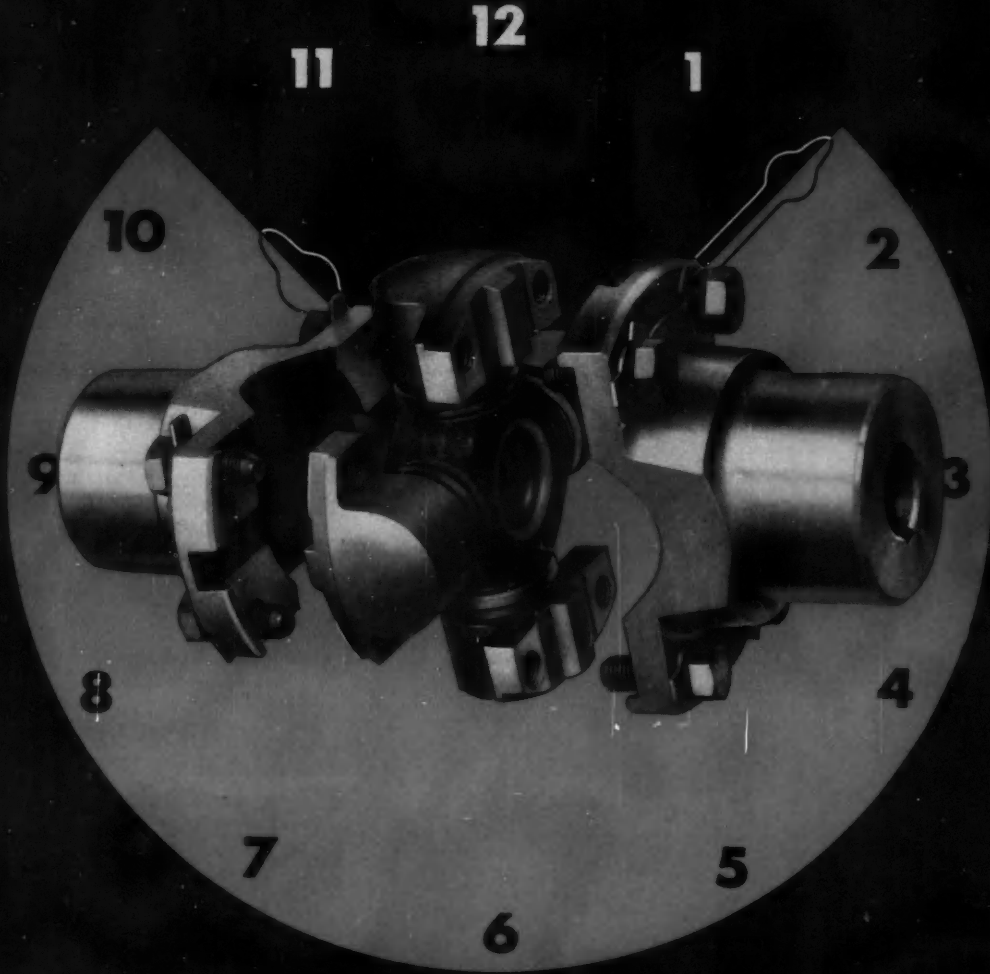

ON THE ROAD OR IN THE FIELD

Manufacturers recommend that universal joints be removed, cleaned, lubricated and replaced at regular intervals. The down-time required can be reduced from hours to 15 minutes—by equipping your product with MECHANICS UNIVERSAL JOINTS. The bearing assembly can be lifted out, simply by removing the screw bolts. Because keys and keyways are ground to fit there is no danger of destroying the original accurate alignment and balance. Let our engineers show you how this exclusive feature of MECHANICS UNIVERSAL JOINTS will give your product competitive advantages.

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Roller Bearing BW

• For Cars • Trucks • Tractors • Farm Implements • Road Machinery •

• Aircraft • Tanks • Busses and Industrial Equipment •

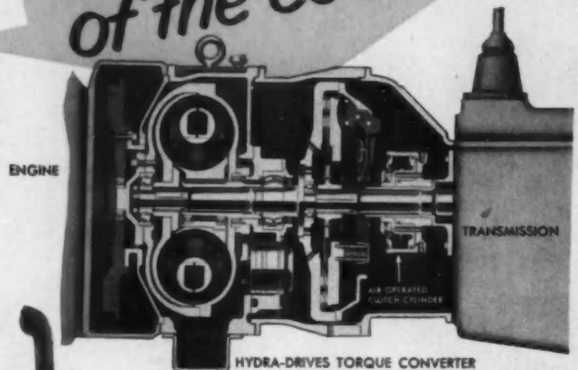
Now! Many Of The Advantages Of Power Shift Transmission

at a fraction of the cost!

HYDRA-DRIVES®

TORQUE CONVERTER WITH A STICK SHIFT TRANSMISSION!

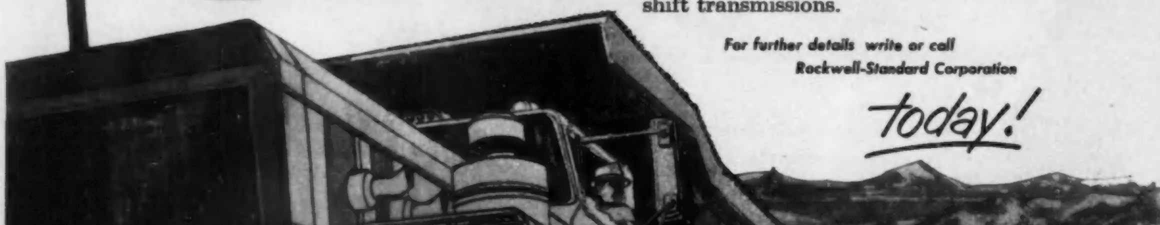
Lower in initial costs, Rockwell-Standard's Hydra-Drives Converter with stick shift transmission reduces operating and maintenance costs on heavy-duty off-highway trucks. You get these five major advantages plus many others:



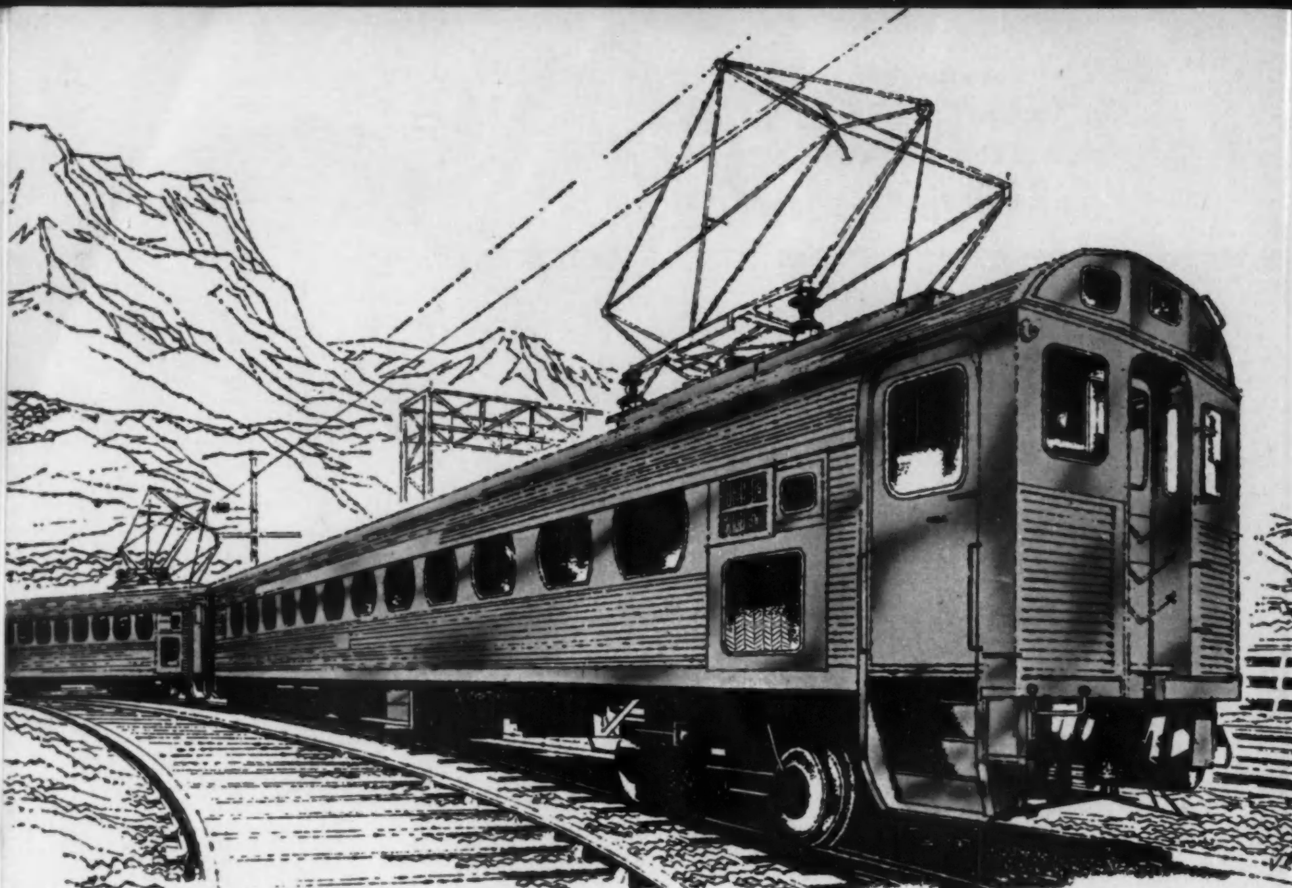
1. Up to 80% of shifting is eliminated. Select a transmission ratio to fit the haul, and let the converter handle the changing load conditions with a minimum of gearing. Any required shifting can be done while truck is in motion!
2. Greatly reduces shock loading on all drive components.
3. Clutch adjustments and wear problems minimized.
4. A minimum of driver training is required.
5. Cost is hundreds of dollars less than full power shift transmissions.

For further details write or call Rockwell-Standard Corporation

today!



ANOTHER PRODUCT OF **ROCKWELL-STANDARD** CORPORATION



Light as a 128-Passenger Feather

Because it makes practical use of the remarkable strength-weight ratio of the austenitic stainless steels, this all-stainless steel railroad passenger car weighs **25 tons less than other so-called modern equipment.**

It is an important contribution to railroad operating economy and efficiency because its stainless steel structure guarantees millions of miles of service between overhauls —its gleaming exterior requires no paint.

Designed and built by The Budd Company, it is considered one of the greatest engineering achievements of the century—made possible **only** by that brawny beauty stainless steel.

In your product engineering when weight is a problem and strength a necessity the answer can be found in stainless steel's unique combination of strength, durability and beauty.

J&L leads the industry in melt shop standards for stainless steel—the point where quality starts, **and engineering achievement begins.**

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SHEET • STRIP • BAR • WIRE

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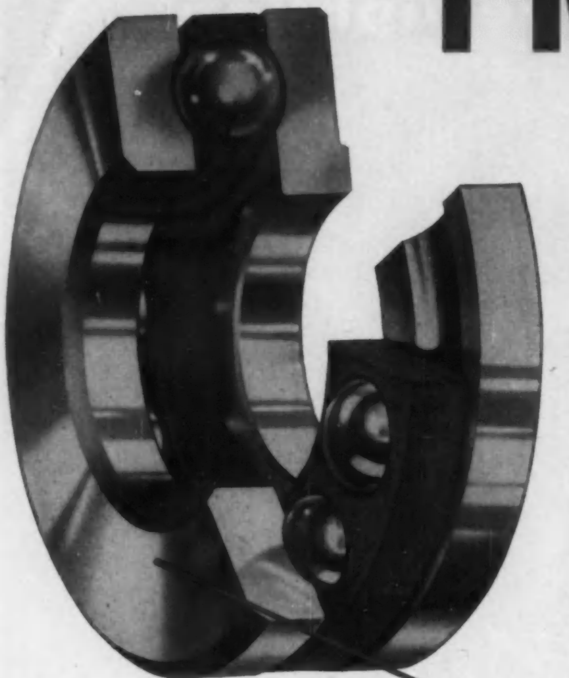
PRECISION



in Aetna Bearings:

Flatness to .00003″

Finish to 5 micro inches

Bore and O.D. Tolerances to .0002″

Parallelism to .0001″

Concentricity to .0002″

Squareness to .0003″

Illustrated is the Optical Flat—only one of the many exceedingly precise instruments which insure the maintenance of these exacting precision standards.

Aetna Bearing Precision is as close to perfection as it is possible to achieve with advanced production methods, extremely accurate precision equipment, constant inspection-checking with special fine-measurement gages, and the integrity of a skilled, experienced personnel.

Each individual process in the entire production procedure is checked and inspected for exact conformity to absolute pre-determined specifications from the receipt of raw material through to completion and final assembly—then checked and inspected again as a completed unit for accuracy, smoothness and operating efficiency.

The result is longer service life—greater ease of installation—and continued, smooth-running anti-friction performance. *You have a better operating product when it is equipped with Aetna Bearings.*

PRECISION PARTS

held to the same exacting standards, produced in quantity at low cost to your exact specifications. Sizes up to 38″ O.D. Surface finishes, parallelism and structural characteristics as specified.

You are invited to submit blueprints, quantities and delivery requirements for quotation.

AETNA BALL AND ROLLER BEARING COMPANY

Aetna

DIVISION OF PARKERSBURG-AETNA CORPORATION • 4600 SCHUBERT AVE. • CHICAGO 39, ILL.

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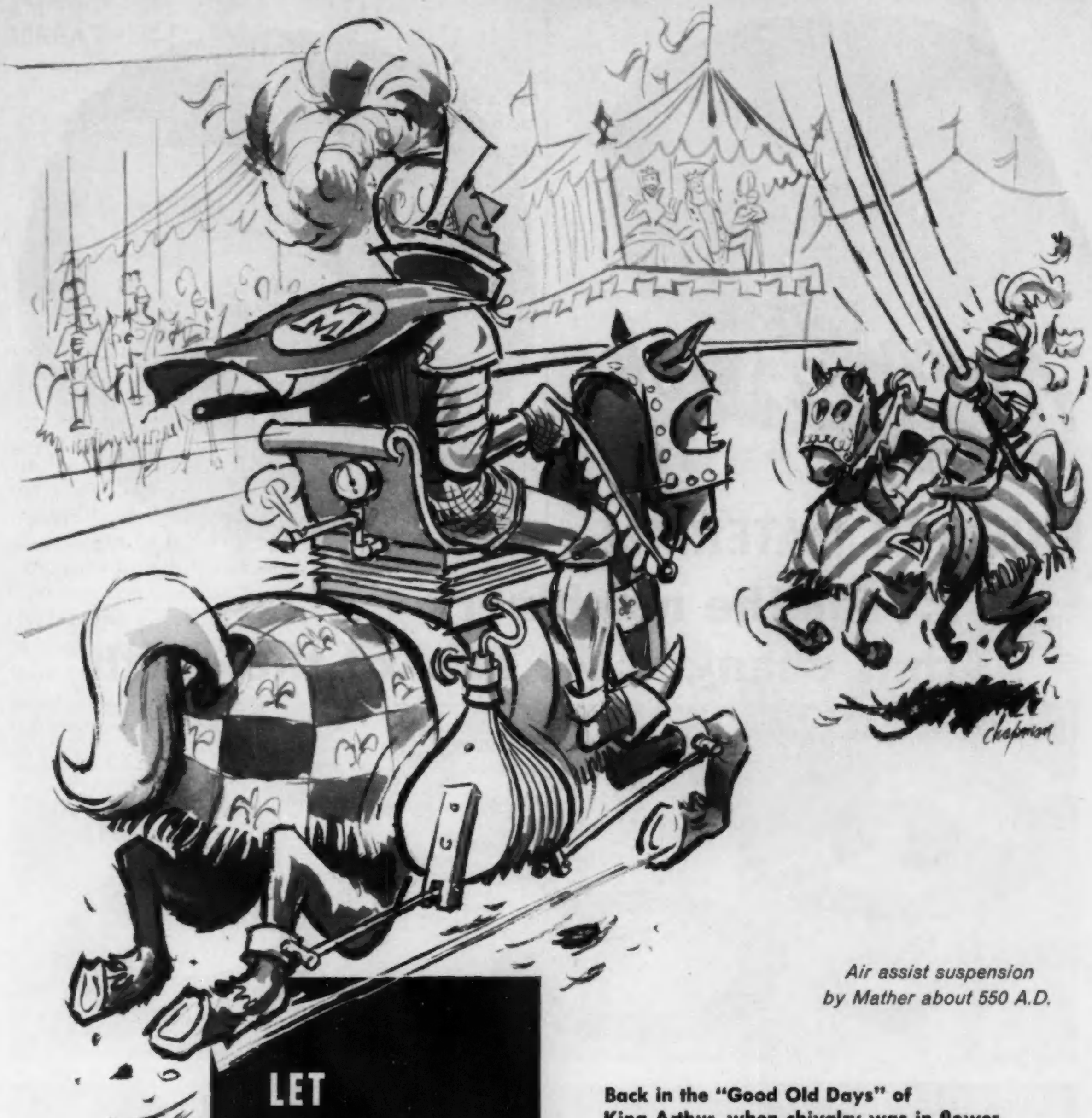

Air assist suspension
by Mather about 550 A.D.

BREATHER-FILTER

protects housings, crankcases, storage tanks.

The Air-Maze breather-filter keeps dust out of engine and compressor crankcases, gearcases, hydraulic equipment, liquid storage tanks and machinery. Types and sizes available in both oil-wetted and oil bath models to protect every vented housing.

In the oil-wetted type, dust is impinged on a series of oil-wetted wire baffles. In the oil bath type, used where the dust concentration is unusually high, the filter media is enclosed in a bowl. Outside air must first pass through the oil, then the filter media, before entering crankcase or housing. Also functions as a backfire flame arrester.

Available in sizes from 1/8" to 3 1/2". Permanent, all-metal, easily cleanable. Write for booklet BC-453. Air-Maze Corporation, Department SJ-10, Cleveland 28, Ohio. (Subsidiary of ROCKWELL-STANDARD Corporation)

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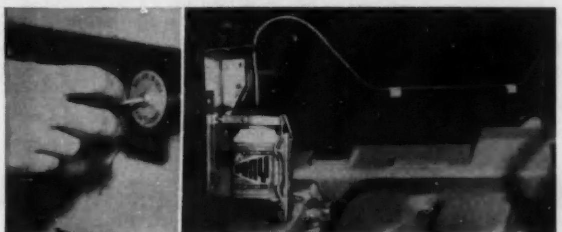
INSTNSTART*

STARTS COLD DIESEL & GASOLINE ENGINES INSTANTLY!

INSTNSTART insures quick starts for cold diesel and gasoline engines all year 'round. (Until an engine reaches normal operating temperature it is a cold engine.) The driver or pilot pulls a knob at his fingertips releasing enough fluid necessary to sustain combustion regardless of weather conditions. INSTNSTART APPLICATORS employ our economical pressurized can of Spray Starting Fluid. This safe, convenient, closed system has been well received in the U. S. and abroad. Quicker starts with INSTNSTART eliminate down-time and prolong engine and electrical system life. It can be installed in minutes with a screwdriver and drill.

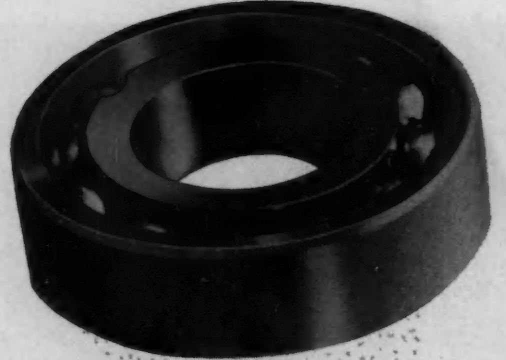


*Patent Pending

▲A cover, not shown, protects the mechanism.

SPRAY PRODUCTS CORPORATION

P.O. Box 844 • Camden 1, New Jersey • NOrmandy 3-7040



BEARINGS WEARING EXCESSIVELY?

Try LOW COST **LISLE** *Magnetic* **PLUGS**

Abrasive ferrous chips from original machining, plus particles that are constantly flaking off working parts, cause unnecessary wear to bearings, bushings, and other precision components.

You can prolong the service-free life of your product, and increase customer satisfaction, by installing LISLE MAGNETIC PLUGS in place of ordinary drain or fill plugs.

LISLE MAGNETIC PLUGS attract and hold these chips and particles — materially reducing wear.

Write for catalog and test samples.

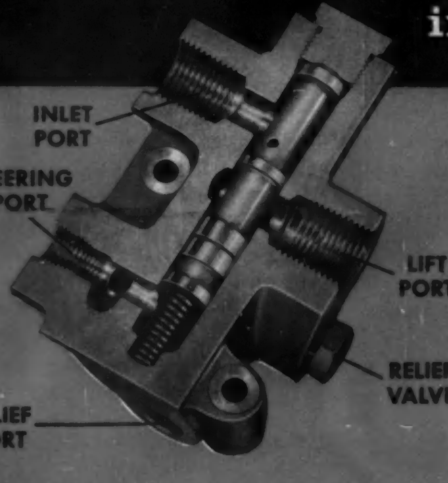
LISLE

CORPORATION

CLARINDA, IOWA

DYNAMIC DIFFERENCE

in hydraulic performance



BULLETIN HY1A contains performance and installation data on the complete line of Webster positive displacement gear type pumps, fluid motors and valves. Write for your copy.

Call the man from Webster

. . he's one of a staff of engineers, specially trained in hydraulic application. He can help you solve special problems when hydraulics become a part of your design!

photo courtesy of THE FRANK G. HOUGH CO., Libertyville, Illinois

Webster

HIGH CAPACITY FLOW DIVIDERS

Material moving magic! 20 cubic feet at a bite, this highly maneuverable front-end loader cuts big piles down to size — without missing a beat. Hydraulics play an important roll here — in power steering, in powering the bucket. But there's only *one* hydraulic pump. A Webster flow divider supplies *both* hydraulic circuits — and permits each to be operated *simultaneously* at different pressures from a *single pump!*

There are more advantages . . . Webster flow dividers operate at pressures up to 2000 psi, capacities to 60 gpm. They're small, compact to fit easily in tight quarters on mobile equipment. Adapt easily and economically to your product and the job.

When *you* plan hydraulics, plan on Webster . . . *for the dynamic difference that pays!*

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC

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our 50th year

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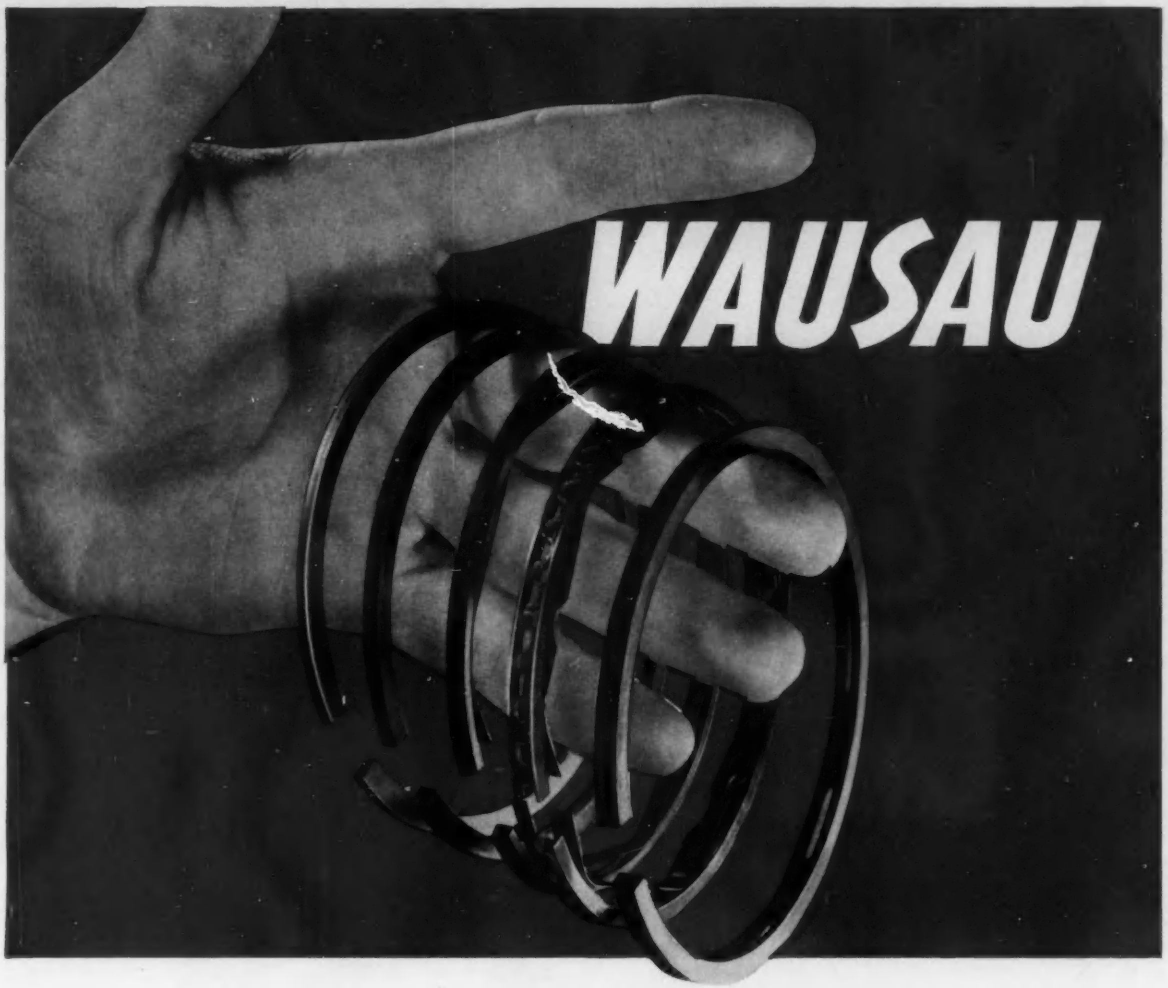
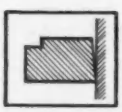
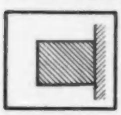


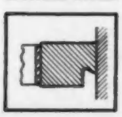
How to select a set of rings for heavy-duty engines



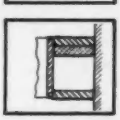
Top Ring — Should be specially alloyed for high impact resistance and fatigue and wear resistance. Example: WAUSAU HT-100 TORSIONAL COMPRESSION (Available in all standard compression ring types).



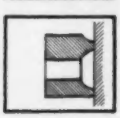
Second Ring — Should be designed for quick seating but with proper tension to insure proper blowby control and drag-free operation. Example: WAUSAU TAPER FACE COMPRESSION.



Scraper Ring — Scraper ring must be specially designed for proper balance between blowby and oil control functions (may be used with inner spring if desired). Example: WAUSAU SUPER SCRAPER.



Oil Ring — Should be scuff-proof and seat quickly. Multiple piece design should include center section designed to dissipate heat and prevent clogging. Example: WAUSAU OILSAVR, the free-running ring with the safety center unit.



Bottom Ring — Should be auxiliary oil control ring properly ported for adequate drainage with adequate unit pressure for maximum oil control. Example: WAUSAU CHANNEL OIL.

A heavy duty ring set should be designed so that all rings in it operate in harmony with each other, to do the complete job of giving long life and the full-rated horsepower of your engines. WAUSAU Heavy Duty Piston Rings are specified as standard equipment for America's finest automotive vehicles. Technical bulletins on request.

WAUSAU
MOTOR PARTS COMPANY
2600 Eau Claire St., Schofield, Wis.